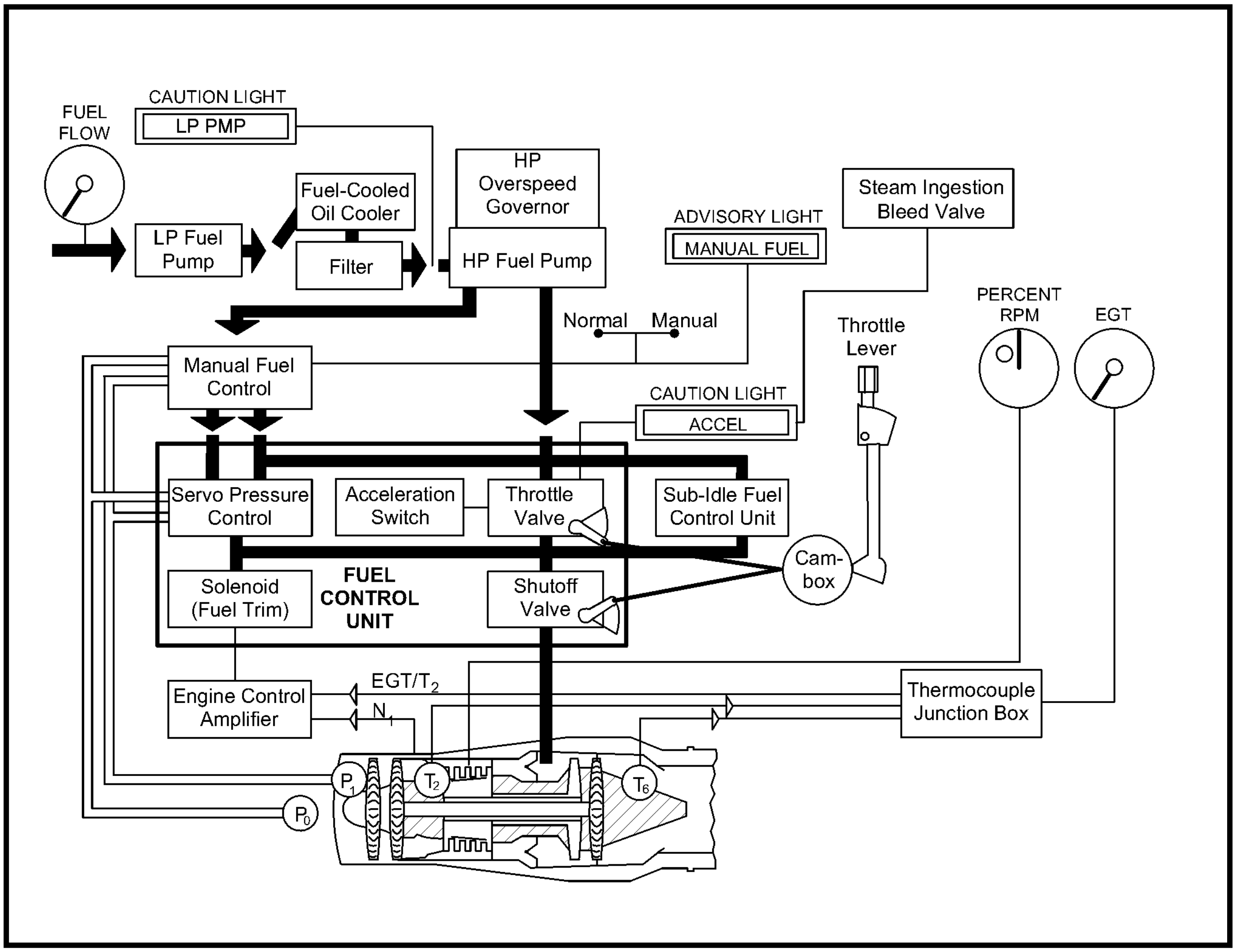
NAVAL AIR TRAINING COMMAND

NAS CORPUS CHRISTI, TEXAS

CNATRA P-1278 (9-98) PAT

ENGINEERING



LECTURE GUIDE

BOOK 1

1998

T-45C LECTURE GUIDE

CHANGE SUMMARY PAGE

CHANGE NUMBER	DATE ENTERED	CHANGE DESCRIPTION	INITIALS
1	7/31/00	Incorporated	TSC
2	3/2/01	Incorporated	TSC
3	10/05/01	Incorporated	TSC
4	11/07/02	Incorporated	TSC
5	12/15/03	Incorporated	TSC
6	3/31/04	Incorporated	TSC
7	6/22/05	Incorporated	TSC

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LECTURE GUIDE

COURSE/STAGE: TS, ADV & IUT / Engineering

LESSON TITLE: Introduction to T-45C Configuration

LESSON IDENTIFIER: T-45C TS, ADV & IUT ENG-01

LEARNING ENVIRONMENT: Classroom

ALLOTTED LESSON TIME: 1.3 hr

TRAINING AIDS:

* Wall Charts
  T-45C Cockpit
* Figures
  Fig 1: T-45C General Description
  Fig 2: Electrical System Block Diagram
  Fig 3: T-45C Engine
  Fig 4: T-45C Fuel System Diagram
  Fig 5: T-45C Hydraulic System Block Diagram
  Fig 6: T-45C Landing Configuration
  Fig 7: Landing Gear Controls and Indicators
  Fig 8: Wheel Brake/Anti-Skid System Block Diagram
  Fig 9: Nose Wheel Steering Major Components
  Fig 10: Arresting Hook Operation
  Fig 11: T-45C Flight Controls
  Fig 12: Canopy System and Controls
  Fig 13: Ejection Seat and Controls
  Fig 14: Command Ejection Selector/Seat Light Switch (Aft Cockpit Only)
  Fig 15: OBOGS
  Fig 16: Environmental Control System
  Fig 17: CNI Cockpit Controls
  Fig 18: Display System and Controls

(9-98) CHANGE 1

TRAINING AIDS (cont.):

Fig 19: Display System
Fig 20: ACS
Fig 21: HUD Controls/Indicators
Fig 22: T-45C Wing Pylon (Underside View)
Fig 23: Cockpit Armament Controls/Indicators
Fig 24: Warning Light Panel
Fig 25: Caution Advisory Light Panel

STUDY RESOURCES:

* T-45C NATOPS Flight Manual, A1-T45AC-NFM-000

LESSON PREPARATION:

Read:

* Part I, Chapter 2, "Systems," T-45C NATOPS Flight Manual, A1-T45AC-NFM-000

REINFORCEMENT: N/A

EXAMINATION: N/A

ENGINEERING CONTENTS

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LESSON OBJECTIVES

1.4.14.3.1.2
Receive overview of T-45C general specifications

1.4.4.3.1.1
Receive overview of electrical system

1.4.6.3.1.1
Receive overview of engine system

1.4.7.3.1.1
Receive overview of fuel system

1.4.8.3.1.1
Receive overview of hydraulic system

1.4.19.3.1.1
Receive overview of flaps/slats, speed brake systems

1.5.4.1.1.1.2
Receive overview of the landing gear system

1.4.10.3.1.1
Receive overview of brake system

1.4.11.3.1.1
Receive overview of anti-skid system

1.4.9.3.1.1
Receive overview of NWS system

1.4.12.3.1.1
Receive overview of launch bar system

1.4.13.3.1.1
Receive overview of tail hook system

1.4.14.3.1.1
Receive overview of flight control system

1.3.5.1.4.1
Receive overview of canopy and ejection seat

1.4.16.3.1.1
Receive overview of OBOGS

1.4.15.3.1.1
Receive overview of ECS

1.4.5.3.1.1
Receive overview of instrument system

1.4.18.3.1.1
Receive overview of CNI system

1.4.18.4.3.4
Receive overview of the display system to include information on the flight quality HUD

1.4.17.3.1.1
Receive overview of ACS

1.4.19.5
Receive overview of air data recorder (ADR) system

1.4.4.3.1.2
Receive overview of centralized warning system (CWS)

MOTIVATION

You must learn enough about aircraft systems operation so that in the event of a malfunction, you can make proper decisions concerning safe flight completion.

OVERVIEW

This first of 25 lessons on the T-45C aircraft provides an overview of its primary and secondary systems. After completing this lesson on the T-45C, you will have a basis for understanding the more detailed system presentations to come.

In this lesson we will discuss the:

* T-45C aircraft general description
* T-45C major systems
  - Makeup and function of each system
  - Location of associated controls and indicators
* Other T-45C aircraft systems
* Centralized warning system (CWS)

REFRESHER

* Recall the basic aircraft systems you studied in Aviation Preflight Indoctrination and those you studied and used on the T-34.

Sg 1, fr 2
Lesson Organization

T-45C CONFIGURATION

* **Overview**
* Major aircraft systems overview
* Other T-45C aircraft systems
* Centralized warning system (CWS)

Sg 1, fr 3
Fig 1: *T-45C General Description*

PRESENTATION

I. T-45C overview **1.4.14.3.1.2**

A. General description

1. Dimensions

a. Wing span: 30 ft, 10 in

b. Length: 39 ft, 5 in

c. Height (to top of fin): 13 ft, 5 in

2. Airframe

a. Moderately swept wing with 2 degrees dihedral

NOTE: A small stall fence on each wing and strategically placed vortex generators aid in wing boundary layer control.

b. Stabilator utilizes swept design, 10 degrees anhedral

c. Control surfaces hydraulically operated except for the rudder which is mechanical

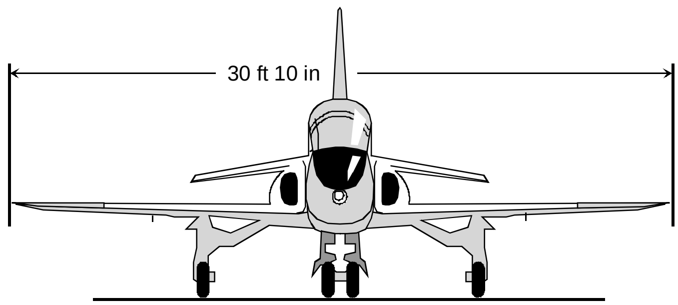
d. Wing pylons permit carriage and delivery of a variety of training weapons

e. Design: U.S. Navy version of British Aerospace Hawk

B. General performance characteristics

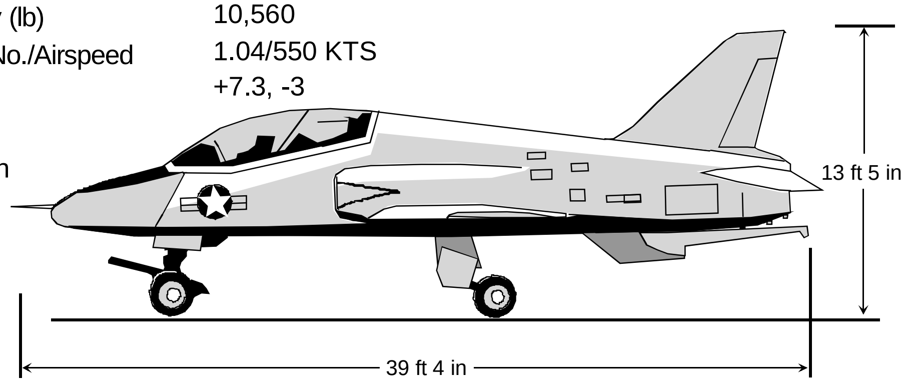
1. Takeoff gross weight (lb): 14,500 land/14,200 CAT launch

2. Usable fuel weight (lb): 2776 JP-4/2,904 JP-5



T-45C
Performance Parameters

Takeoff Gross Weight Land/Cat (lb)	14,500/14,200
Usable Fuel Weight JP-4/JP-5 (lb)	2776/2904
Operating Weight Empty (lb)	10,560
Max Permissible Mach No./Airspeed	1.04/550 KTS
Max g	+7.3, -3



NOTE: Max g is a design specification. Actual operating limitations are contained in the T-45C NATOPS Manual Chapter Four with interim changes.

Figure 1: T-45C GENERAL DESCRIPTION

3. Operating weight empty (lb): 10,560

4. Max permissible Mach/airspeed (clean loading): 1.04/550 KIAS whichever is less

5. Max g: +7.3, -3

   NOTE: Max g is a design specification. Actual operating limitations are contained in the T-45C NATOPS Manual Chapter 4 with interim changes

6. The T-45C is not an all-metal A/C. Some components, i.e., ailerons, speedbrakes, and main gear doors, are made of “super plastics”

PROGRESS CHECK

Question 1 — 1.4.14.3.1.2
What is the takeoff gross weight of the T-45C?

ANSWER: 14,500 land, 14,200 carrier

Question 2 — 1.4.14.3.1.2
What are the g limitations of the T-45C?

ANSWER: +7.3, -3

II. Major aircraft systems overview

A. Electrical system **1.4.4.3.1.1**

1. Description

a. Consists of engine-driven, 28 VDC generator

b. Two 24 VDC batteries

c. Two AC inverters

d. Respective essential and non-essential power distribution buses

2. Function: provides 28 VDC, 26 VAC, and 115 VAC to support on-board electrical systems, aircraft starting, and emergency power

3. Control location: power panels on right console, both cockpits, provide system status (voltmeters) and control

B. Engine system **1.4.6.3.1.1**

1. Description (F405-RR-401): single, non-afterburning twin spool turbofan with a two-stage low pressure (N_1) and a five-stage high pressure (N_2) compressor driven by respective single-stage low and high pressure turbines, with self-starting gas turbine start capability

2. Function

a. Produces static installed thrust of 5527 lb at sea level

b. Provides torque to drive aircraft accessories--i.e., generator, hydraulic pumps, and fuel pumps

c. Supplies bleed air for the oxygen system, cockpit and fuel tank pressurization, and the environmental control system (air conditioning)

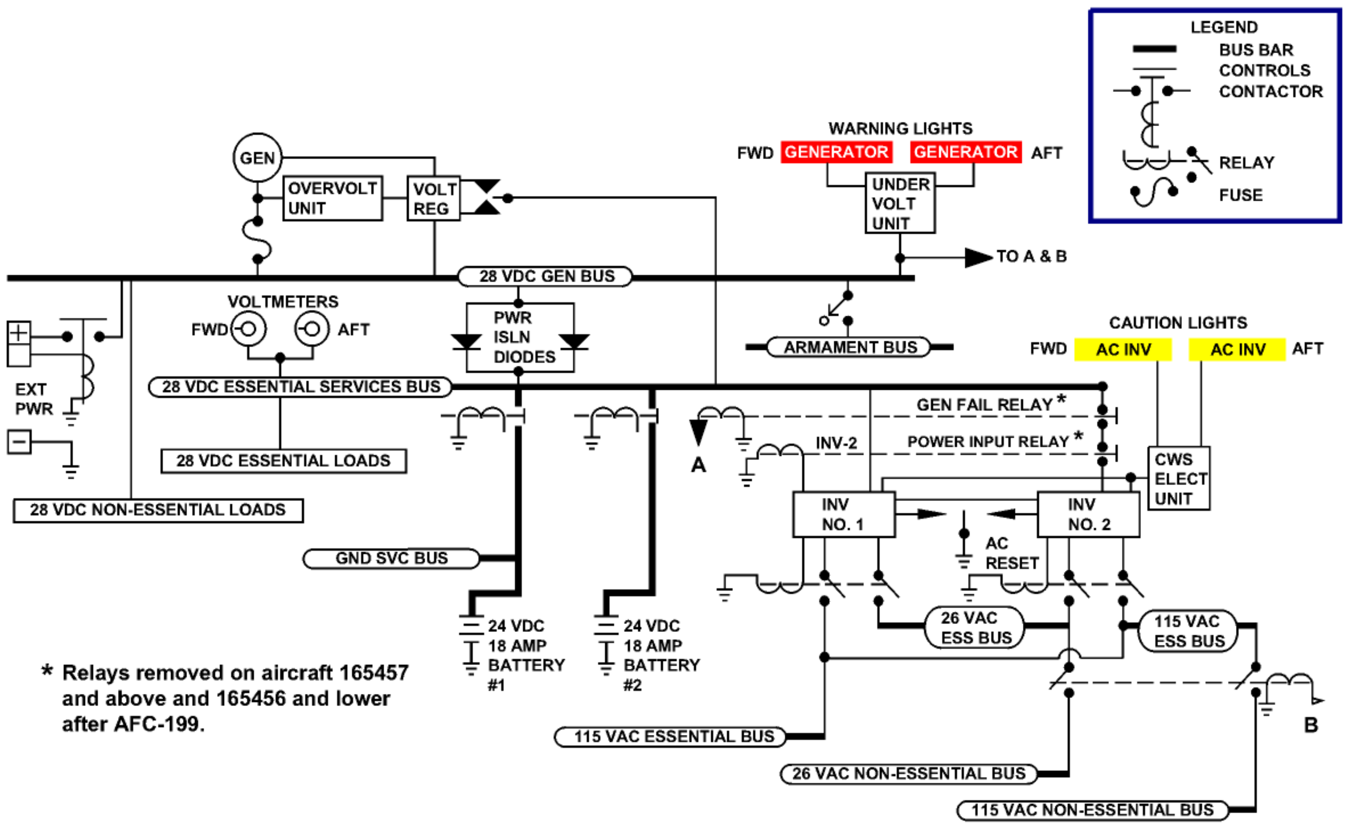
Sg 3, fr 2
Lesson Organization

T-45C CONFIGURATION

* Overview
* **Major aircraft systems overview**
* Other T-45C aircraft systems
* Centralized warning system (CWS)

Sg 3, fr 3
Fig 2: *Electrical System Block Diagram*

Sg 3, fr 4
Fig 3: *T-45C Engine*



* Relays removed on aircraft 165457 and above and 165456 and lower after AFC-199.

Figure 2: ELECTRICAL SYSTEM BLOCK DIAGRAM

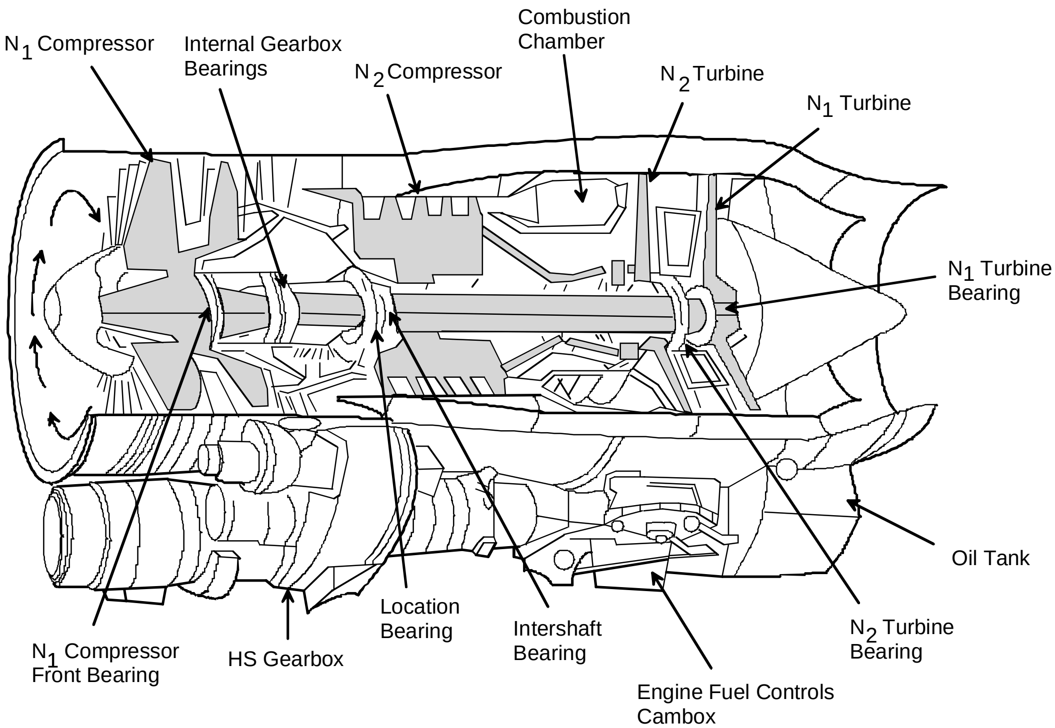


Figure 3: T-45C ENGINE

3. Control location: throttle quadrant and associated starting and fuel control switches--left consoles, both cockpits

PROGRESS CHECK

Question 3 — 1.4.6.3.1.1
How many stages in the N_1 and N_2 compressors?

ANSWER: 7 stages

Sg 3, fr 5
Fig 4: *T-45C Fuel System Diagram*

C. Fuel system **1.4.7.3.1.1**

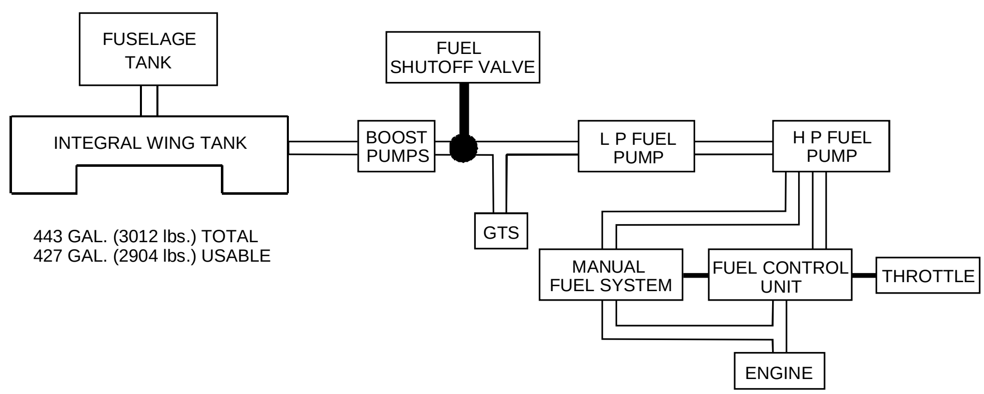


Figure 4: T-45C FUEL SYSTEM DIAGRAM

1. Description: 443-gal internal fuel supply carried in fuselage tank and integral wing tank

2. Function

   a. Pressure-fed with boost pumps assist to ensure fuel supply is uninterrupted under negative-g conditions

b. Provides fuel for engine and gas turbine starter

3. Control location

a. Fwd cockpit only: FUEL SHUTOFF T-handle, fuel shutoff panel, left console; allows pilot to manually secure flow of fuel to engine and GTS

b. Left intake, refueling, defueling switches

D. Hydraulic (HYD) system **1.4.8.3.1.1**

LESSON NOTES

Highlight the fact that the hydraulic system provides the only means of controlling the ailerons and stabilator. With total hydraulic failure in flight, ejection will be the only option.

Sg 3, fr 6
Fig 5: *T-45C Hydraulic System Block Diagram*

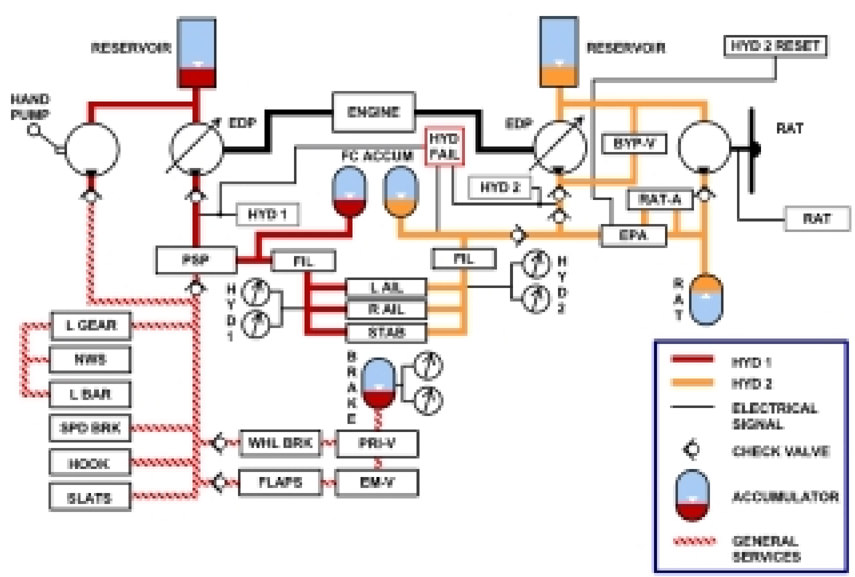


Figure 5: T-45C HYDRAULIC SYSTEM BLOCK DIAGRAM

1. Description: two independent systems (HYD 1 and HYD 2) consisting of engine-driven pumps (EDPs) reservoirs, and accumulators. An associated part of HYD 2 is an emergency HYD system, with ram air turbine (RAT) supplying emergency hydraulic power back-up for HYD 2 EDP

2. Function: both independent systems provide constant 3000 psi

   a. HYD 1 powers flight controls (stabilator and ailerons) and general services (speed brakes, flaps, slats, landing gear, wheel brakes, anti-skid, launch bar, nose wheel steering, and arresting hook)

   b. HYD 2 powers flight controls and emergency assembly package

   c. RAT powers flight controls through emergency HYD system following a failure of the HYD 2 EDP

3. Control location: HYD 2 RESET button--left console, forward of throttle, both cockpits

E. Flaps/slats, speed brakes **1.4.19.3.1.1**

NOTE: Since during normal operation full slat extension occurs with any half or down flap condition, reference to slats is omitted in some subsequent discussion of flaps.

1. Description: flaps inboard at trailing edge of each wing, slats full span on leading edge of wing, and speed brakes on each side of aft fuselage

2. Function

   a. Flaps augment lift at lower airspeeds

   b. Slats decrease stall speed and increase aircraft control and stability

c. Speed brakes increase drag to reduce airspeed rapidly during flight and to allow increased power setting in landing configuration

3. Control location

a. FLAPS/SLATS lever: left console, adjacent to throttle, both cockpits

b. EMER FLAPS switches: lower left instrument panel, both cockpits

c. Speed brake extend/retract switch: throttle grip under mic switch, both cockpits

F. Landing gear system **1.5.4.1.1.1.2**

Sg 3, fr 7
Fig 6: *T-45C Landing Configuration*

1. Description: retractable, tricycle-type gear

a. Each wing-mounted main gear consists of strut assembly, trailing arm suspension unit, conventional split-hub wheel, and single tire

b. Nose gear: conventional forward-retracting shock strut, dual tire system with mountings for launch bar, holdback, and lighting assemblies

2. Function: supports and cushions aircraft during stresses of land-based or carrier launches and landings

3. Control location

Sg 3, fr 8
Fig 7: *Landing Gear Controls and Indicators*

a. LDG GEAR handle: lower left instrument panel, both cockpits

b. EMER GEAR handle: lower left instrument panel, both cockpits

c. TONE button: left of LDG GEAR handle, both cockpits

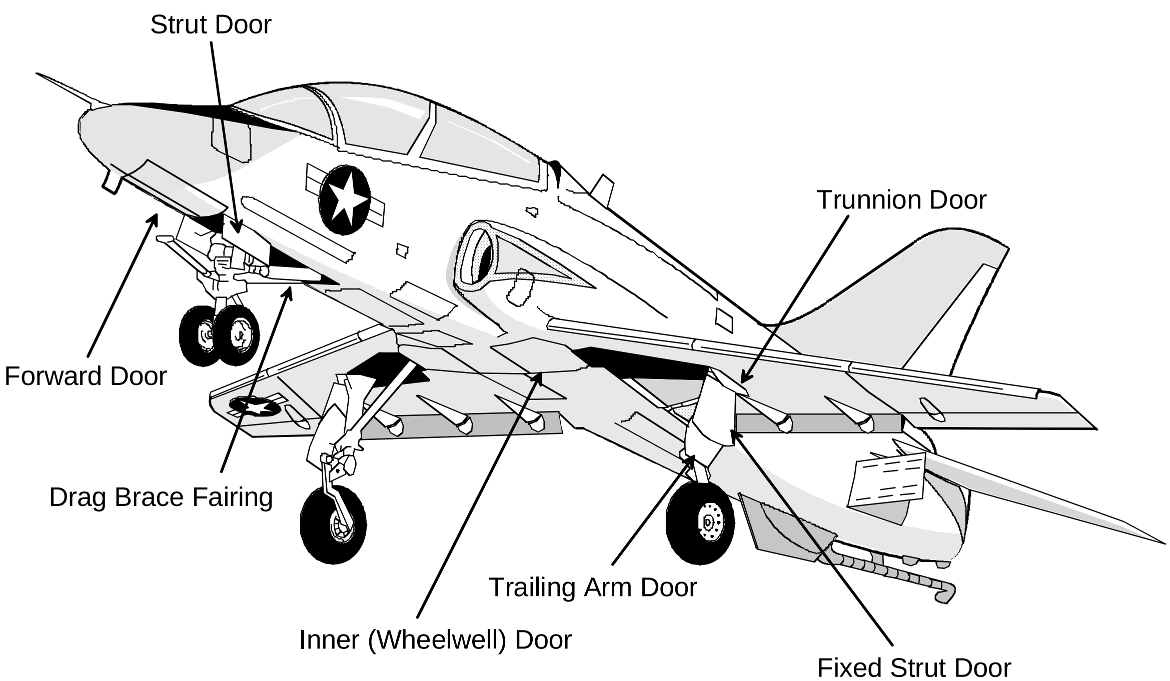


Figure 6: T-45C LANDING CONFIGURATION

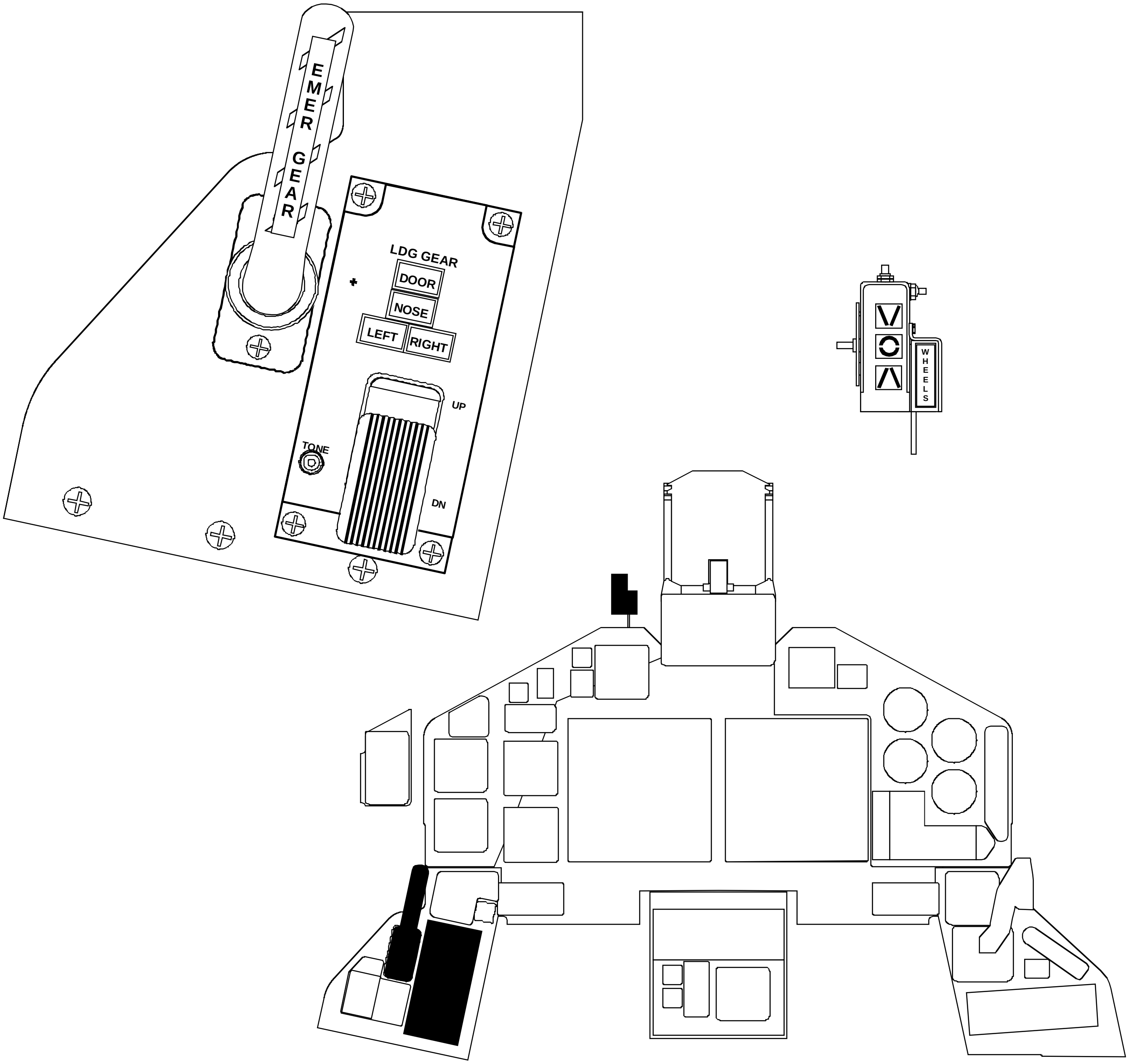


Figure 7: LANDING GEAR CONTROLS AND INDICATORS

Sg 3, fr 9
Fig 8: *Wheel Brake/ Anti-Skid System Block Diagram*

G. Brake system **1.4.10.3.1.1**

1. Description: conventional wheel-mounted, hydro-mechanically boosted self-adjusting braking system, with anti-skid

2. Function: slows/stops aircraft and provides directional control through differential braking if nose wheel steering inoperative

3. Control location

   a. Brake pedals: top of each rudder pedal, both cockpits

   b. PARKING BRAKE handle: lower right instrument panel, fwd cockpit only

H. Anti-skid system **1.4.11.3.1.1**

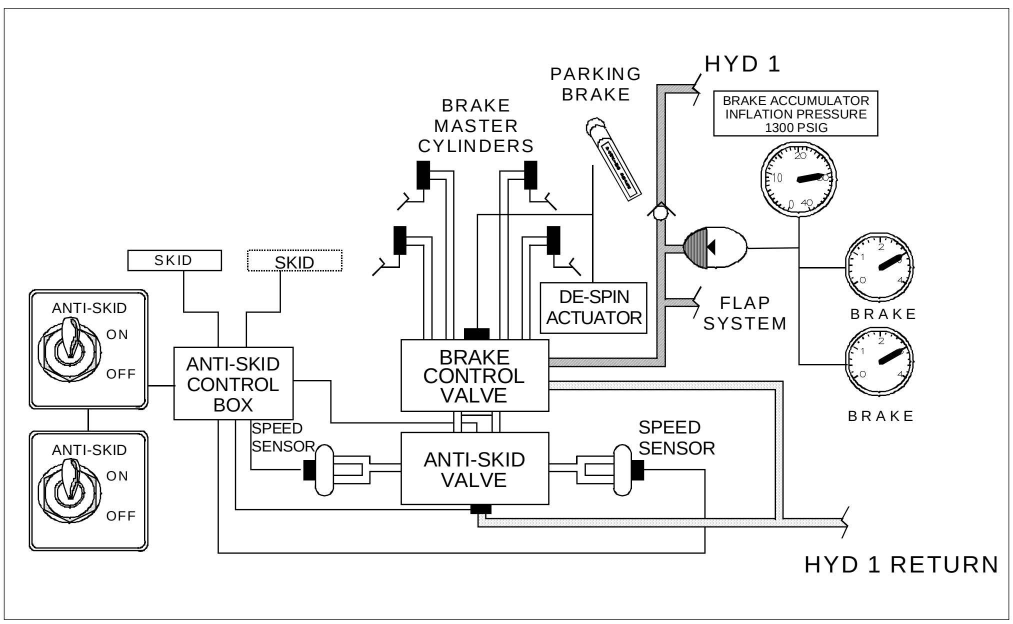


Figure 8: WHEEL BRAKE/ANTI-SKID SYSTEM BLOCK DIAGRAM

1. Description: electro-mechanically controlled, hydraulically operated speed sensing system

2. Function

   a. Prevents wheel skids caused by slippery surfaces or heavy braking

   b. Provides touchdown protection to prevent locked wheels when landing

3. Control location: ANTI-SKID switch--left console, both cockpits

Sg 3, fr 10
Fig 9: *Nose Wheel Steering Major Components*

I. Nose wheel steering (NWS) system **1.4.9.3.1.1**

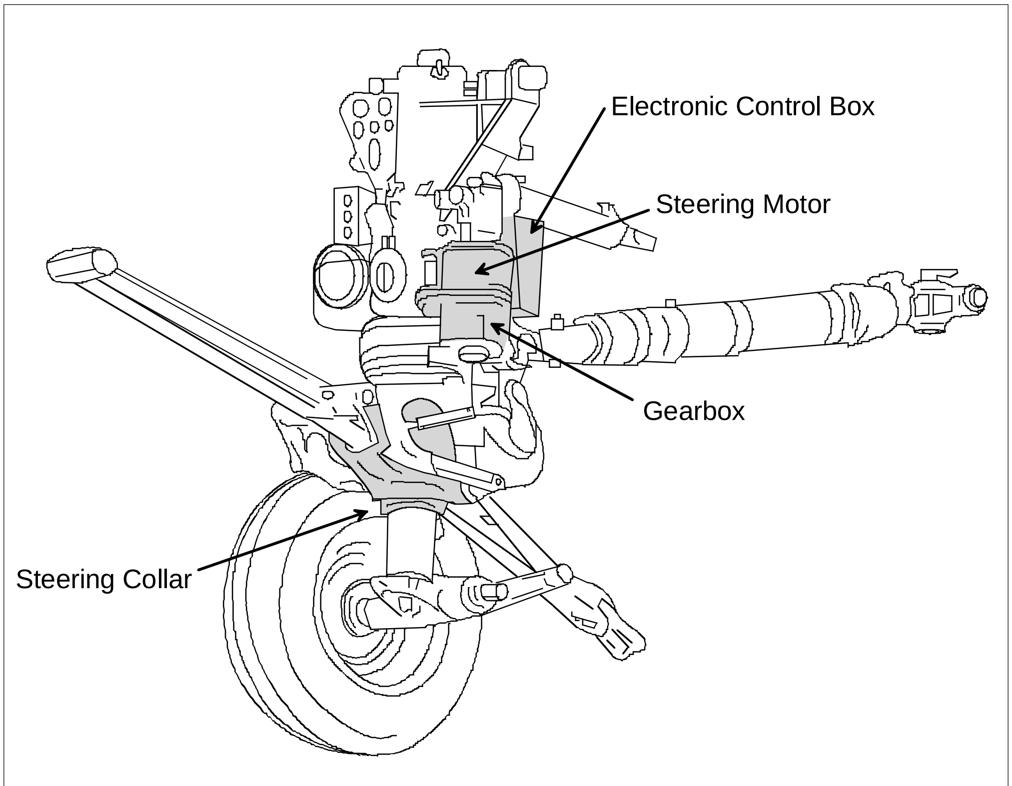


Figure 9: NOSE WHEEL STEERING MAJOR COMPONENTS

1. Description: electrically controlled, hydraulically operated dual-gain power-steering system

2. Function: full-time, low-gain, selectable high-gain nose wheel steering

   a. Low gain provides +/- 12 degrees either side of center for takeoff and landing

Sg 3, fr 11
Fig 10: *Arresting Hook Operation*

b. High gain provides +/- 65 degrees either side of center for aircraft parking

c. When launch bar is extended, nose wheel is disengaged. NWS steering may be selected by pressing and holding the NWS button but travel is limited to +/- 20 degrees either side of center.

3. Control location

a. NWS button: control stick, both cockpits

b. Paddle switch: control stick, both cockpits

c. Rudder pedals: provide electro-mechanical directional input to NWS to steer aircraft

J. Launch bar system **1.4.12.3.1.1**

1. Description: electrically controlled, hydraulically extended, and mechanically retracted launch bar

2. Function: connects aircraft to catapult shuttle during catapult launches

3. Control location: LAUNCH BAR switch--below EMER GEAR handle, lower left instrument panel, fwd cockpit only

K. Arresting hook system **1.4.13.3.1.1**

1. Description: extended by gravity with nitrogen damper and retracted hydraulically

2. Function: extended hook engages deck arresting cable or field arresting gear to stop aircraft

3. Control location

a. Arresting HOOK handle: right instrument panel, both cockpits

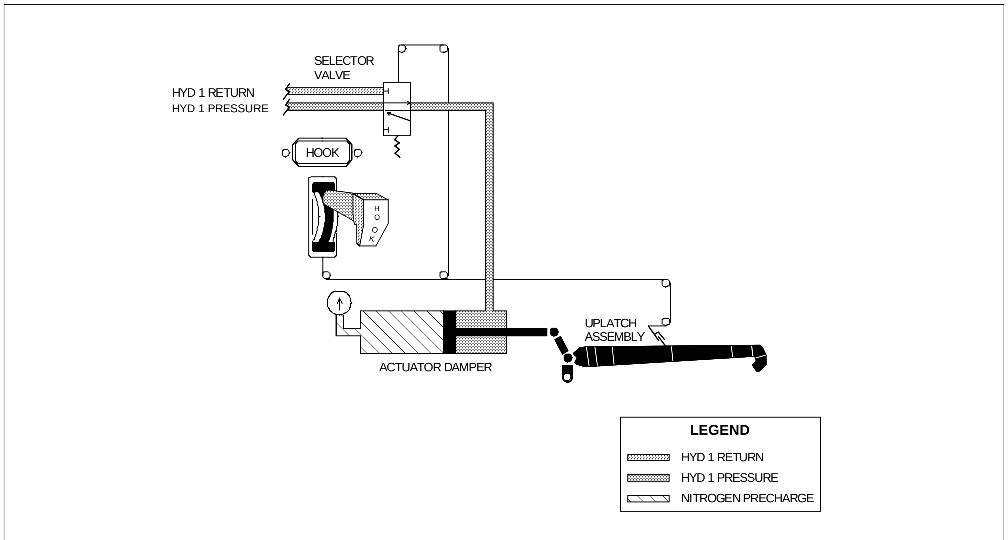


Figure 10: ARRESTING HOOK OPERATION

L. Flight control system **1.4.14.3.1.1**

Sg 3, fr 12
Fig 11: *T-45C Flight Controls*

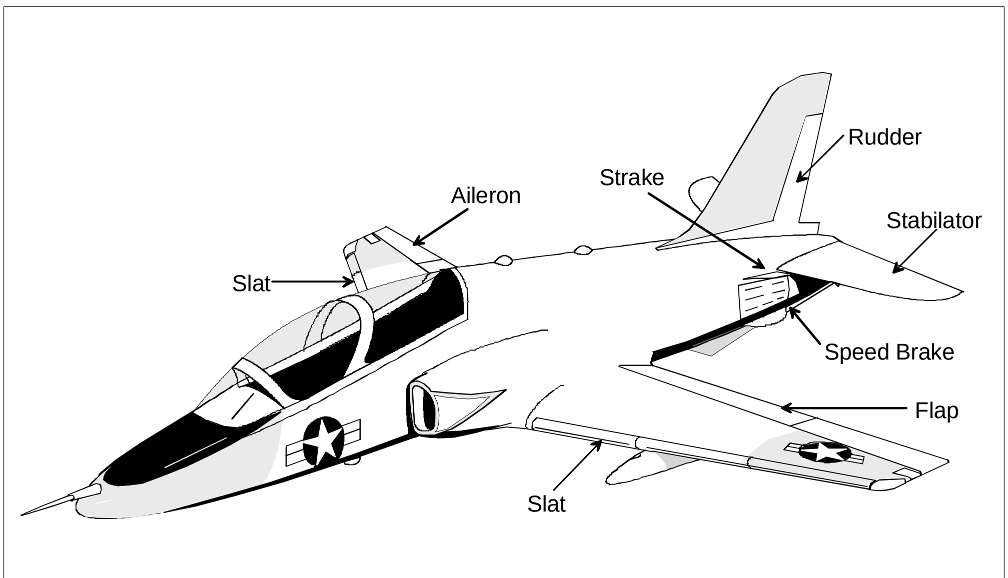


Figure 11: T-45C FLIGHT CONTROLS

1. Description: ailerons, stabilator, and rudder control surfaces

2. Function: provides control of aircraft about roll (longitudinal), pitch (lateral), and yaw (vertical) axes of flight

Sg 3, fr 14
Fig 12: *Canopy System and Controls*

3. Control location

   a. Control stick (including trim switches for aileron and stabilator): both cockpits

   b. Rudder pedals (adjustable): both cockpits

   c. Rudder lock lever: right rudder pedal well, fwd cockpit only

   d. CONTR AUG, STBY STAB TRIM, and RUDDER TRIM switches: trim/engine start panel, left console, aft of throttle, both cockpits

4. Indicator location

   a. AILERON and RUDDER trim, and TAIL PLANE (stabilator) position: left console, forward of throttle, both cockpits

   b. C AUG caution light: caution/advisory panel

M. Canopy and ejection systems **1.3.5.1.4.1**

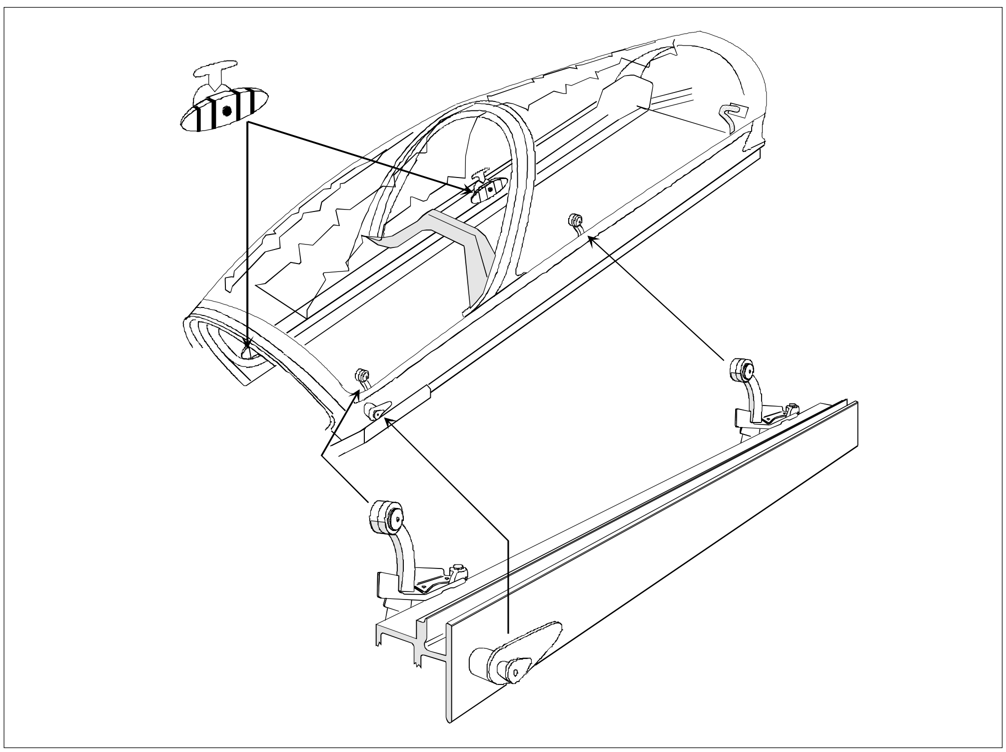


Figure 12: CANOPY SYSTEM AND CONTROLS

1. Canopy

   a. Description: side opening, one-piece molded acrylic, attached to rigid frame, covers both cockpits (manually operated)

   b. Function: provides environmental and atmospheric protection while allowing maximum visibility

   c. Control locations

      (1) Canopy external handle: left side, forward cockpit

      (2) Internal canopy control levers: left side, both cockpits

      (3) Canopy mild detonating cord (MDC) firing handle: right side, both cockpits; allows pilots to shatter canopy for emergency manual egress

2. Ejection seat

Sg 3, fr 15
Fig 13: *Ejection Seat and Controls*

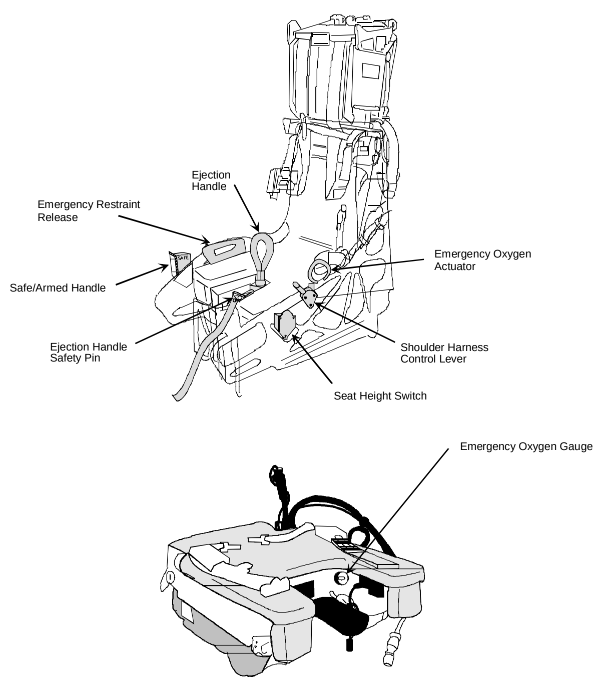


Figure 13: EJECTION SEAT AND CONTROLS

a. Description: ballistic catapult and rocket-powered seat, containing emergency life-support systems

LESSON NOTES

Highlight the fact that when on the ground the aircraft has a zero/zero capability of ejection. When in-flight, changes in roll and pitch can degrade the probability of a safe ejection.

b. Function: provides emergency egress

c. Control location

(1) SAFE/ARMED handle: right side of bucket

(2) Emergency restraint release handle: right side of each seat

(3) Ejection handle: middle, front of each seat bucket

(4) Seat height adjustment and shoulder harness lock lever: left side of seat

Sg 3, fr 16
Fig 14: *Command Ejection Selector/Seat Light Switch*

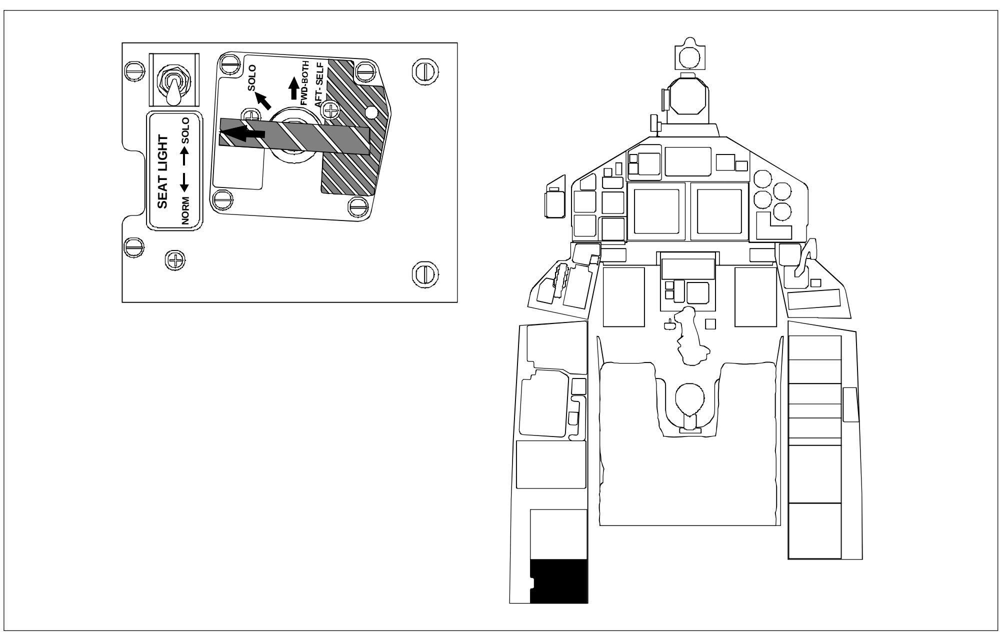


Figure 14: COMMAND EJECTION SELECTOR/SEAT LIGHT SWITCH (Aft Cockpit Only)

(5) Command ejection selector and SEAT LIGHT switch: left console, aft cockpit only

PROGRESS CHECK

Question 4 — 1.3.5.1.4.1
What is the minimum speed and altitude at which the ejection seat may be used?

ANSWER: The T-45C uses a zero/zero ejection seat. Ejection may be accomplished at zero speed and zero altitude when the aircraft is in a level attitude.

N. On-board oxygen generation system (OBOGS) **1.4.16.3.1.1**

Sg 3, fr 17
Fig 15: OBOGS

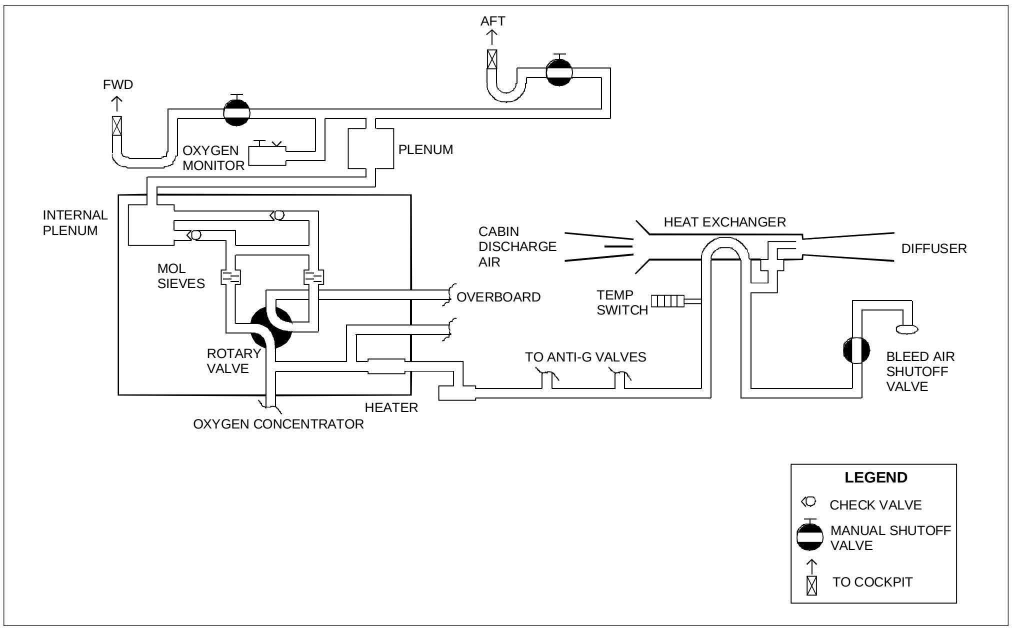


Figure 15: OBOGS

1. Description: consists of engine bleed air shutoff valve, heat exchanger, oxygen concentrator, plenum, and regulator

2. Function: converts engine compressor bleed air to oxygen-rich breathing air and pressurized air for anti-g system

3. Control location: pilot services panel, left console, both cockpits

Sg 3, fr 18
Fig 16: *Environmental Control System*

O. Environmental control system (ECS) **1.4.15.3.1.1**

1. Description: consists of the air conditioning system, the cockpit pressurization system, and the avionics equipment cooling system

2. Function

    a. Converts engine compressor bleed air to conditioned air and distributes it to cockpit ventilation, pressurization, and defog systems

    b. Provides cooled bleed air to avionics bay for equipment cooling

3. Control location: right console, aft of interior lights control panel, fwd cockpit only

Sg 3, fr 19
Flight Instruments

Fig 19: *Display and System Controls*

P. Flight instruments **1.4.5.3.1.1**

1. Description: consist of airspeed, vertical speed, compass, altimeter, and attitude indicating systems

2. Function

    a. Provide primary flight performance data

    b. Provide navigation information

    c. Provide backup instrumentation

3. Control location: throughout cockpit with associated system operation

4. Indication location: on center instrument panel

    a. AOA indicator

    b. AOA indexer

    c. Airspeed indicator

    d. Multi function display (MFD)

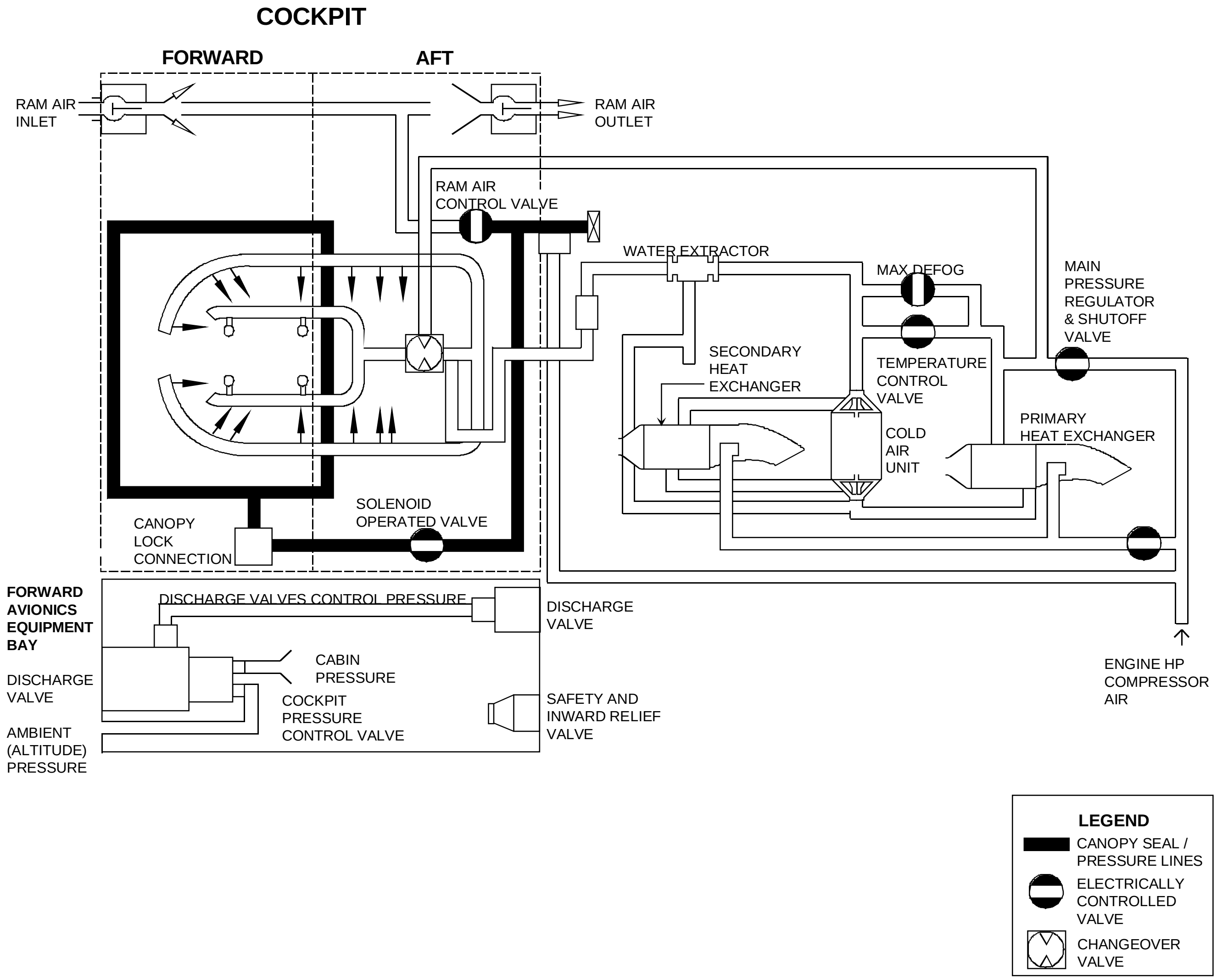


Figure 16: ENVIRONMENTAL CONTROL SYSTEM

(1) Attitude indication

(2) Airspeed/mach

(3) Altitude

(4) Radar altitude

(5) Vertical speed

(6) Horizontal situation indicator (HSI) display

(7) Accelerometer

e. Vertical speed indicator (VSI)

f. Standby attitude indicator (AI)

g. Head-up display (HUD)

h. Standby compass

i. Clock

Q. COMM/NAV instrument (CNI) system **1.4.18.3.1.1**

Sg 3, fr 20
Fig 17: *CNI Cockpit Controls*

1. Description

   a. Communication system: two UHF/VHF radio control panels, COMM control panel, and communication transfer panel

   b. Navigation system: TACAN, VOR/ILS, GPS waypoint, and IFF units

2. Function

   a. Communication system provides cockpit intercom, air-to-air, and air-to-ground communication and generates aural tones for CWS and master alert

   b. Navigation system provides navigation data to primary navigation instruments

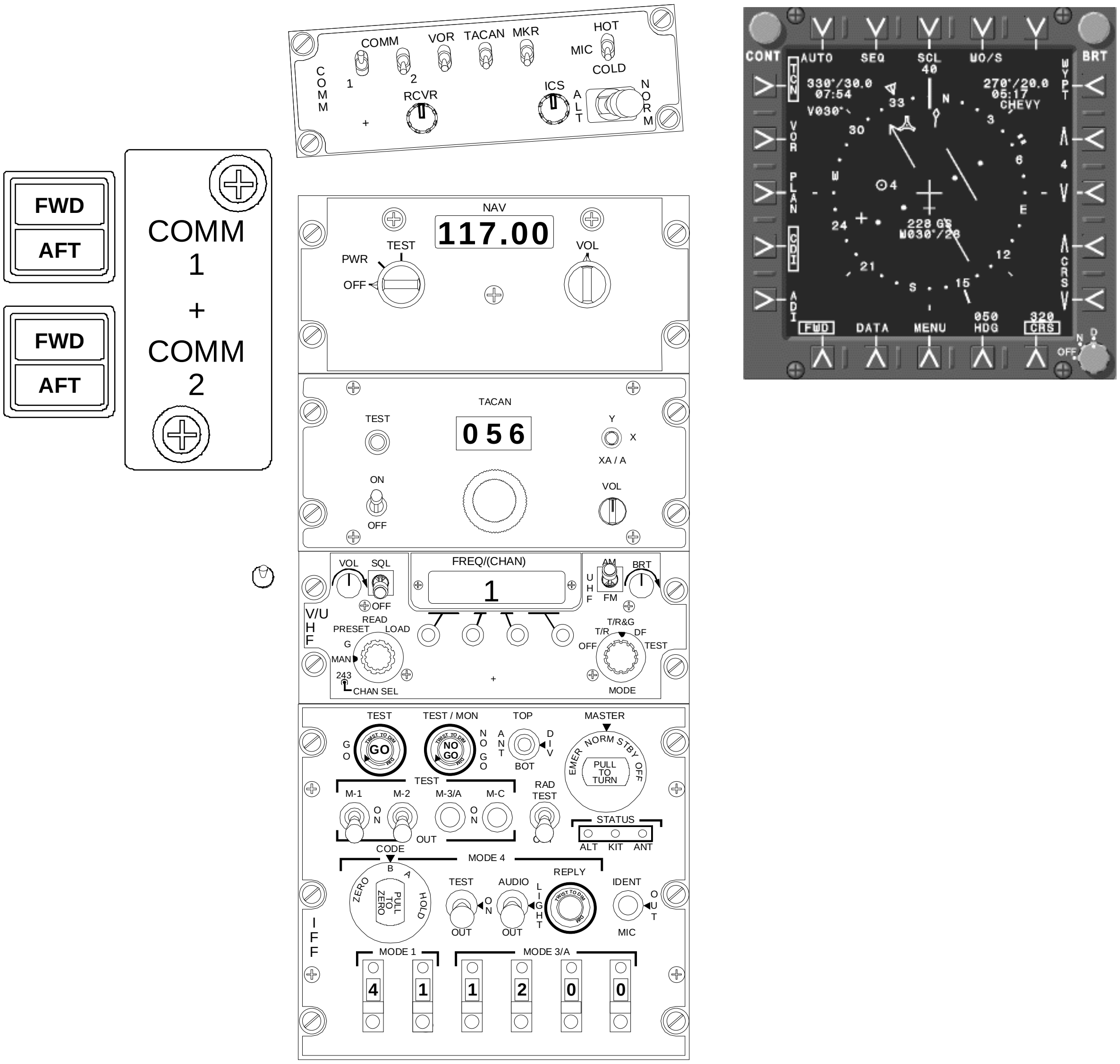


Figure 17: CNI COCKPIT CONTROLS

3. Control location: on respective units--right console, instrument panel, throttle grip, and stick

4. Indicator location: on respective units--right console and instrument panel

Sg 3, fr 21
Fig 18: *Display System*

R. Display system **1.4.18.4.3.4**

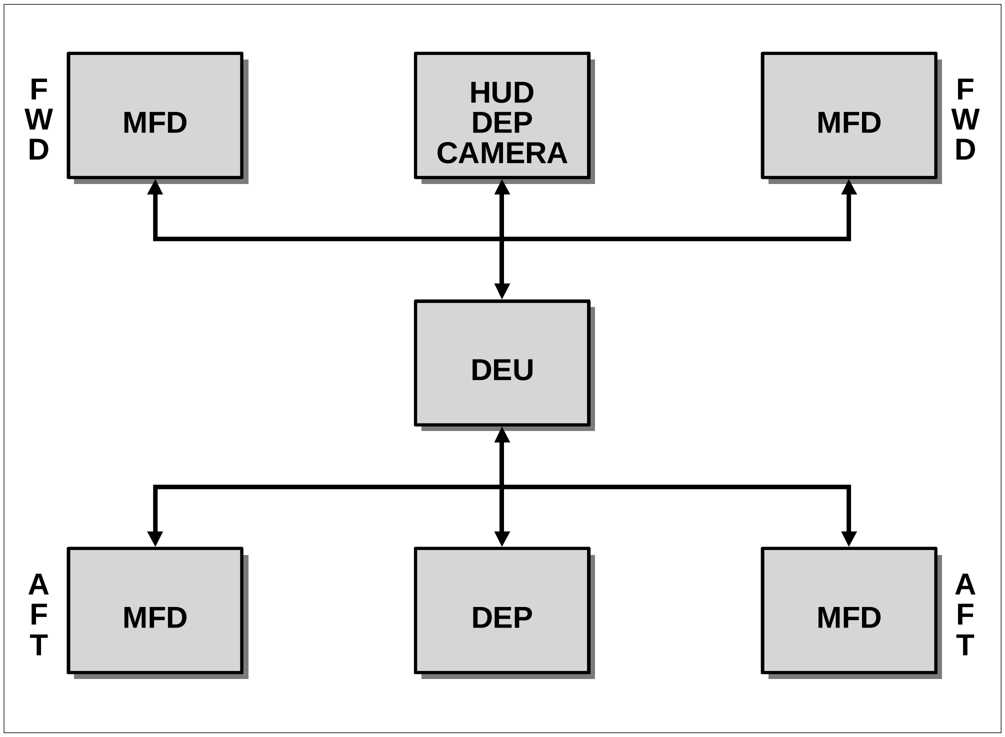


Figure 18: Display System

1. Description

   a. Display system: 4 MFDs, HUD, Data Entry Panel (DEP) and Display Electronics Unit (DEU)

2. Function

   a. Display system provides multiple electronic displays of engine, navigation, weapons and built-in-test (BIT)

Sg 3, fr 22
Fig 19: *Display System and Controls*

3. Control location: on respective units - center instrument panel

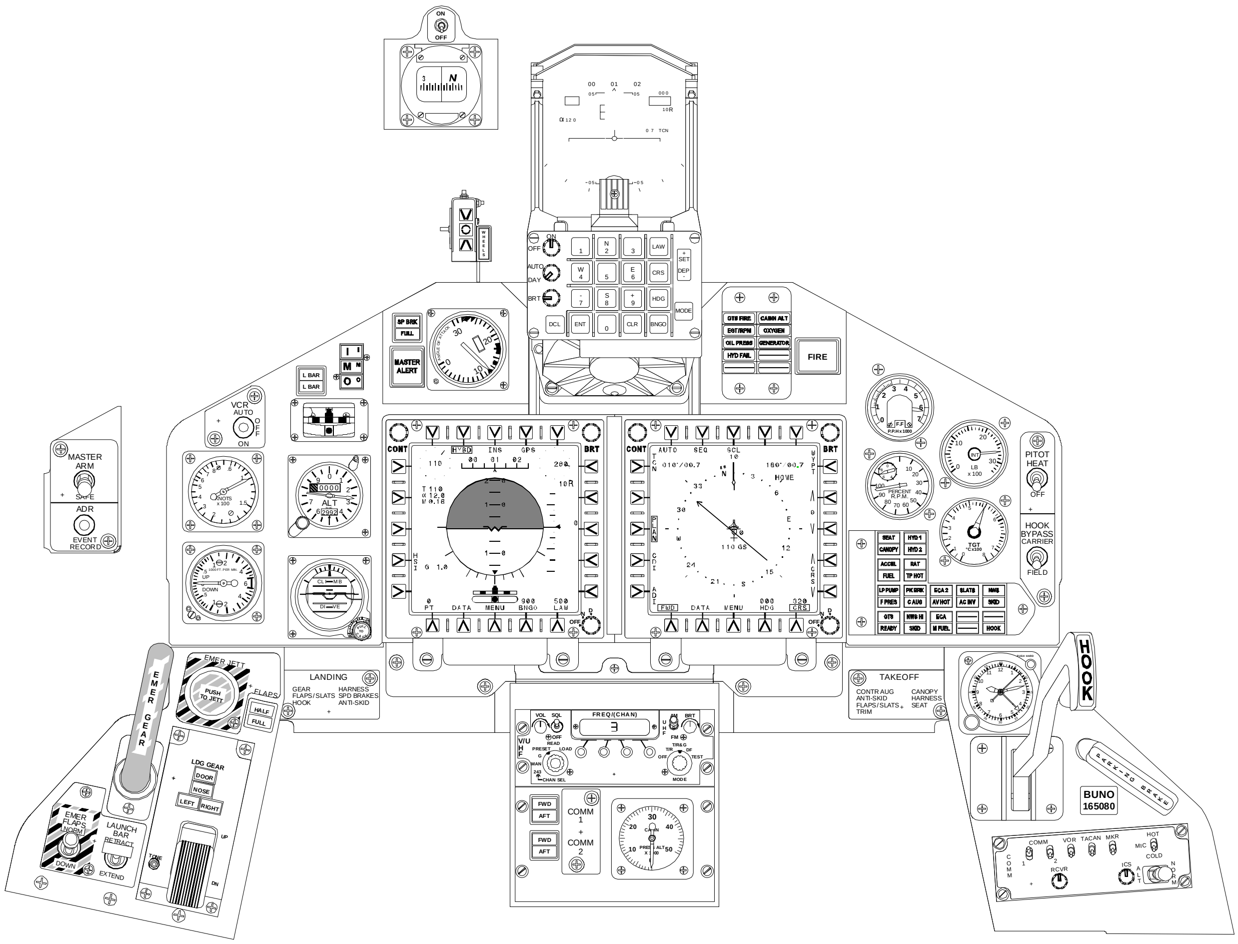


Figure 19: Display System and Controls

Sg 11, fr 2
Lesson Organization

T-45C CONFIGURATION
* Overview
* Major aircraft systems overview
* **Other T-45C aircraft systems**
* Centralized warning system (CWS)

Sg 11, fr 3
Fig 20: *ACS*

III. Other T-45C aircraft systems

A. Armament control system (ACS) **1.4.17.3.1.1**

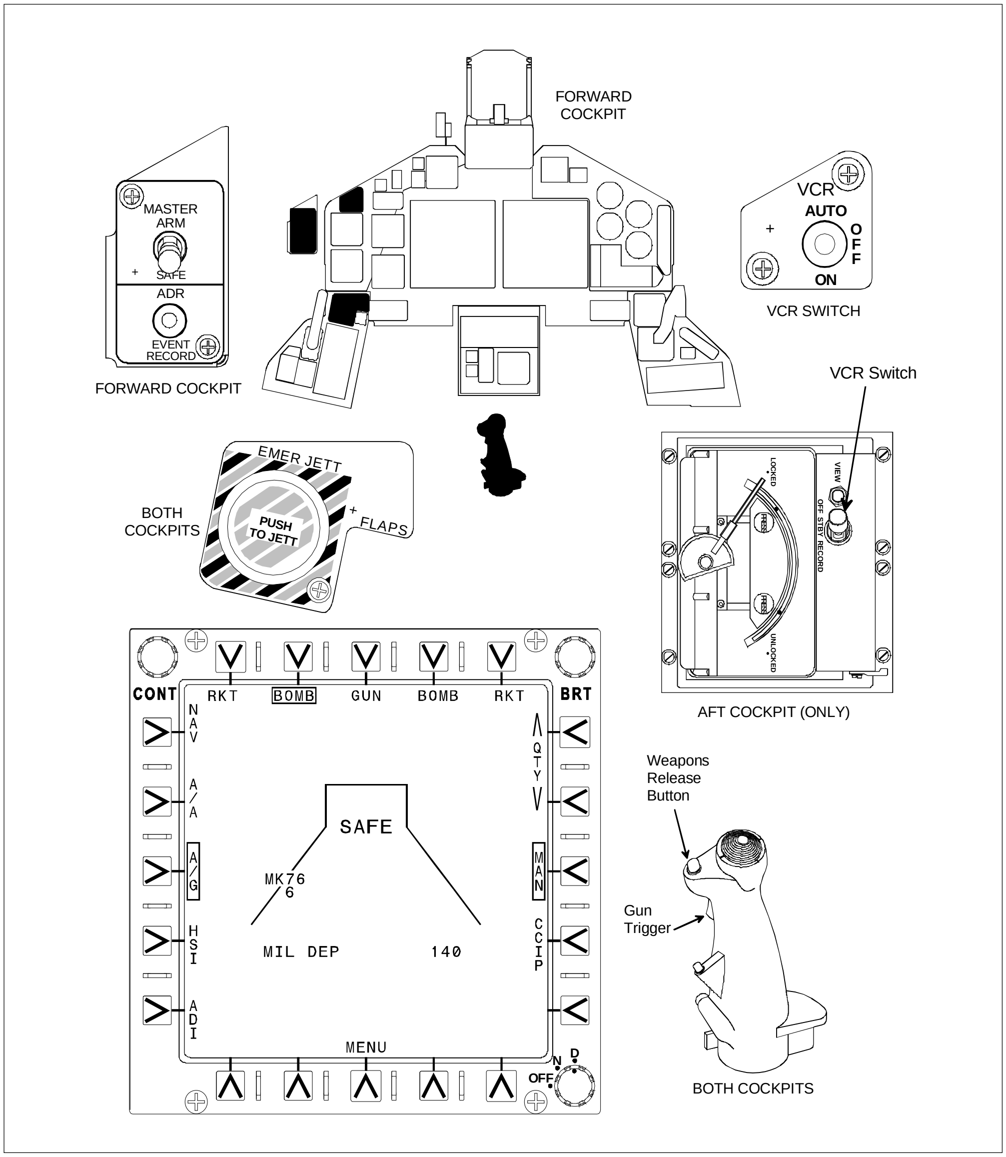


Figure 20: ACS

Sg 11, fr 4
Fig 21: *HUD Controls/Indicators*

Sg 11, fr 5
Fig 22: *T-45C Wing Pylon (Underside View)*

1. Description

   a. Multi function display (MFD) stores displays and cockpit switching logic

   b. Videocassette recording system: periscope mounted sensor head, camera electronics unit, and videocassette recorder

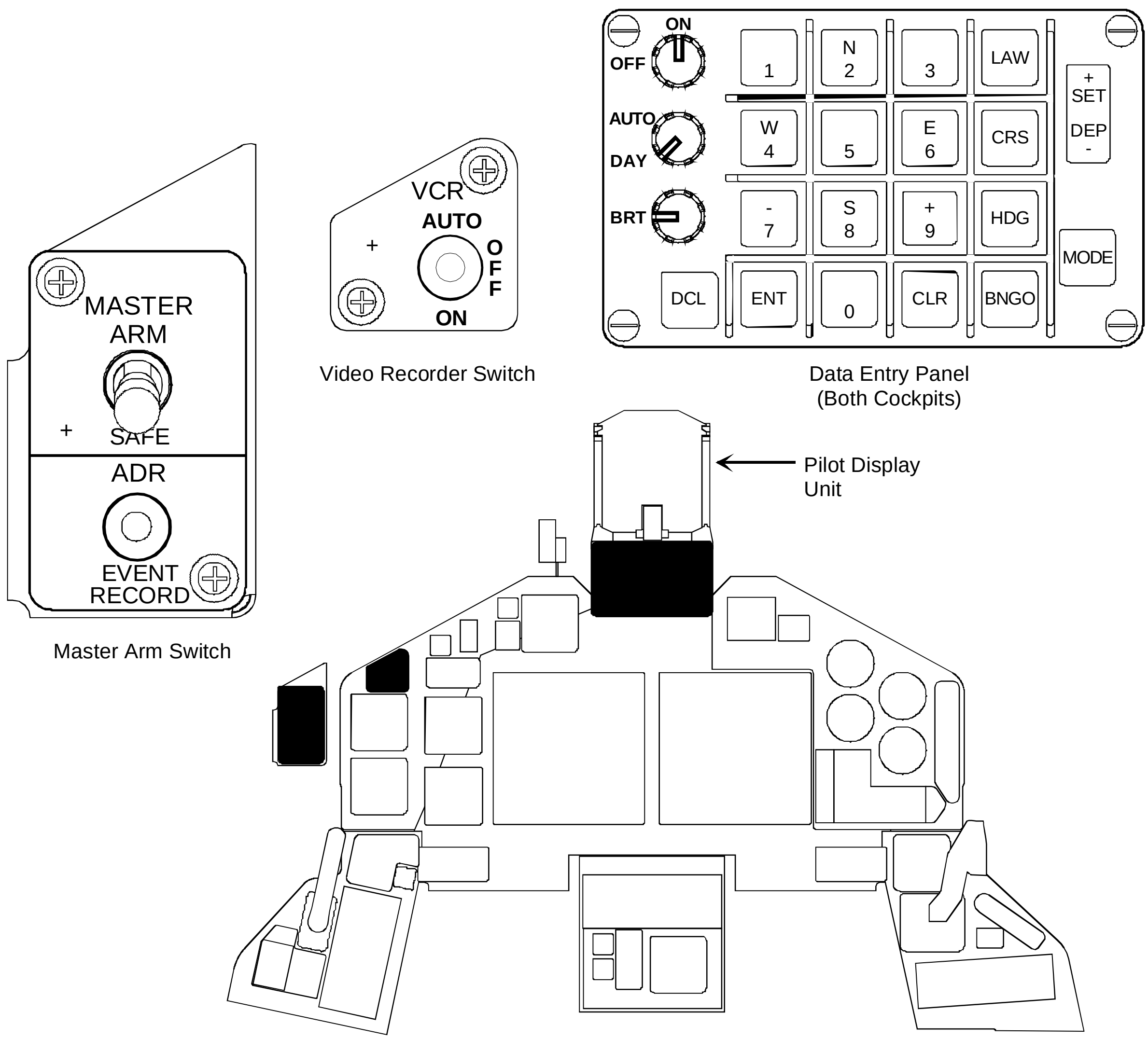


Figure 21: HUD CONTROLS/INDICATORS

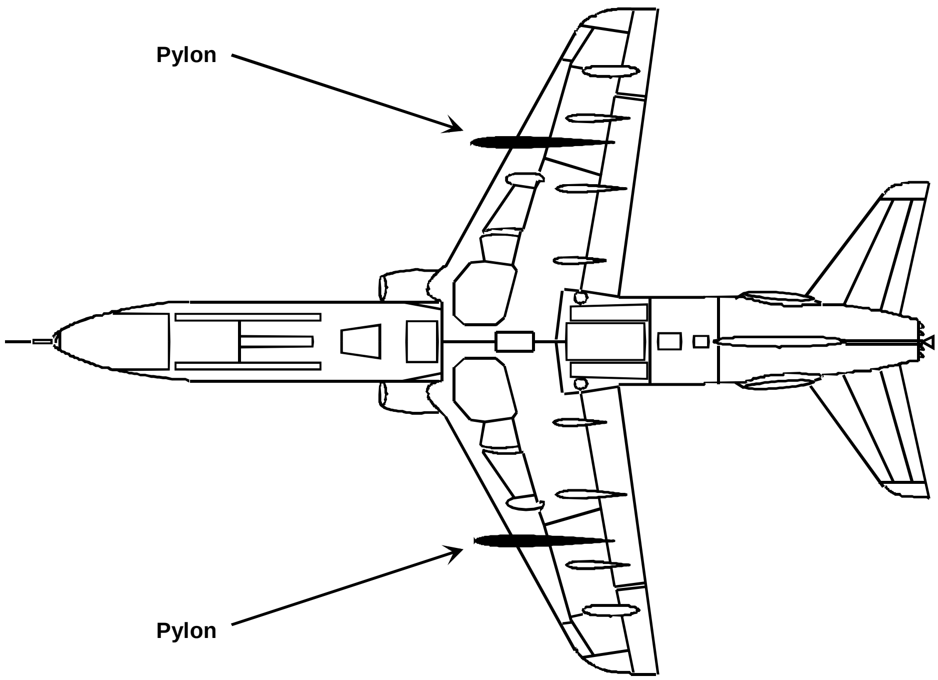


Figure 22: T-45C WING PYLON (UNDERSIDE VIEW)

c. HUD: pilot display unit, display electronics unit, data entry panel (both cockpits)

d. Wing stations: underwing pylons hold multiple practice bomb racks or LAU-68 rocket launchers

e. Gunsight (aft cockpit only)

2. Function

a. ACS: switch, relay logic, and controls used to select and deliver weapons

b. Videocassette system: provides method of recording HUD view, attack display, or navigational display and audio for debriefing and analysis

c. MFD: provides capibilites for weapons management, master arm status and selected delivery modes

d. HUD: provides fwd cockpit attack display for weapons delivery and flight performance data display

e. Wing stations, pylons, and associated racks/ launchers: provide method of carrying and delivering weapons

f. Gunsight: combining glass displayed reticle provides rear cockpit sighting for weapon delivery

Sg 11, fr 6
***Fig 23:** Cockpit Armament Controls/ Indications*

3. Control location

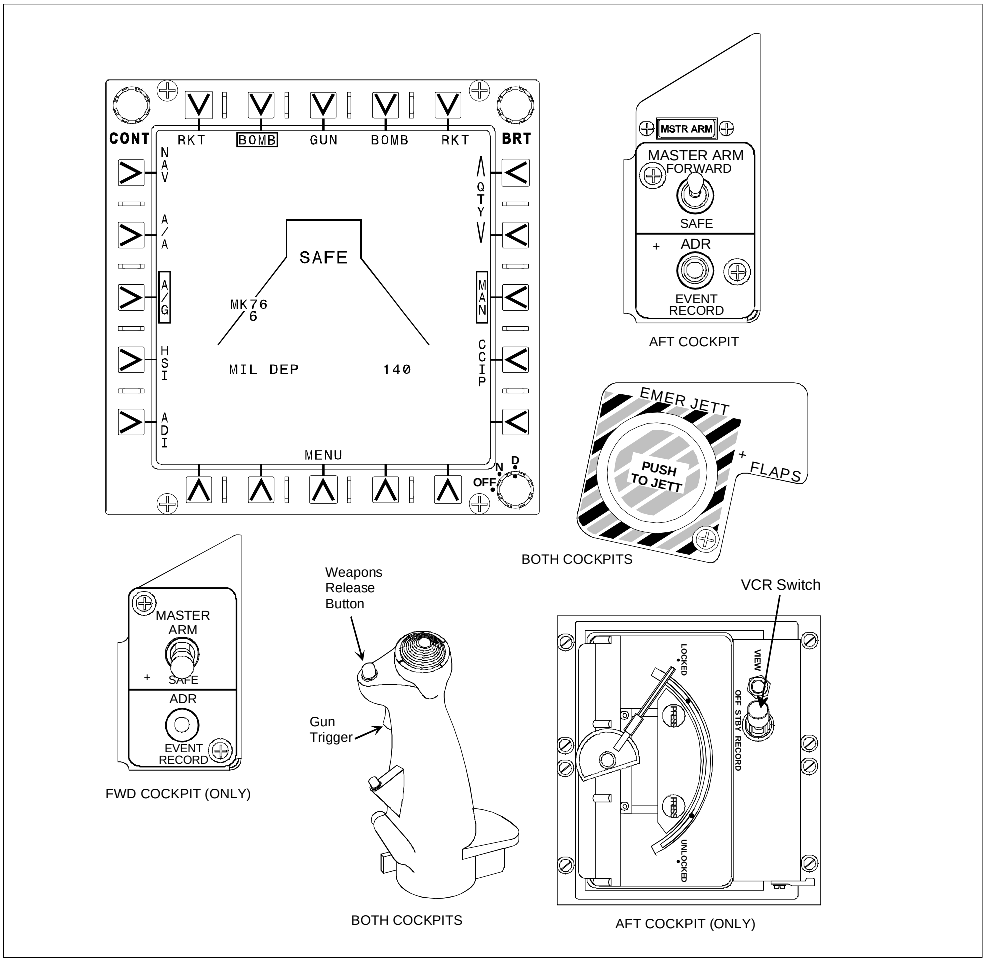


Figure 23: COCKPIT ARMAMENT CONTROLS/INDICATIONS

a. Station select and weapons select stores display either MFD: both cockpits

b. MASTER ARM switch: upper left instrument panel, fwd cockpit only

c. Weapons release button and gun trigger: stick grip in each cockpit

d. MASTER ARMAMENT OVERRIDE switch: middle left center instrument panel, aft cockpit only

e. EMER JETT button: instrument panel, both cockpits

f. Data entry panel: both cockpits

Sg 11, fr 7
Fig 21: HUD Controls/Indicators

g. VCR switch (fwd cockpit): upper left instrument panel

(1) AUTO - VCR operation starts and stops with selection of master armament switch

(2) ON - VCR operation starts

(3) OFF - VCR operation stops, deenergizes VCR if aft cockpit switch is off

h. VCR switch (rear cockpit): video interface module (VIM)

Sg 11, fr 8
Fig 20: ACS

(1) OFF - VCR off

(2) STBY - Pre-threads tape, VCR on, operation controlled by front cockpit VCR switch

(3) RECORD - Initiates recording

(4) VIEW - recording disabled for 18 seconds as tape rewinds; there is no capability to review tape in the T-45

4. Indicator location

a. Stores display on MFD

b. Arm switch: Armament control and ADR event record panel

c. Pilot display unit: upper center instrument panel, attack and navigation displays, fwd cockpit only

Sg 11, fr 9
Air Data Recorder Push Button

Fig 23: *Cockpit Armament Controls/ Indications*

B. Airborne data recording system **1.4.19.5**

1. Description: The airborne data recording system consists of an airborne data recorder (ADR); incident record push button in each cockpit, an ADR BIT panel, and aircraft system sensors

2. Function: The system provides the combined functions of a flight incident recorder, engine usage monitoring, and structural fatigue monitoring

Sg 2, fr 2
Lesson Organization

T-45C CONFIGURATION

* Overview
* Major aircraft systems overview
* Other T-45C aircraft systems
* **Centralized warning system (CWS)**

IV. Centralized warning system (CWS) **1.4.4.3.1.2**

Wall Chart: *T-45C Cockpit*

LESSON NOTES

The CWS will not be taught in this curriculum as a separate, major aircraft system. Each of its indications and the conditions that cause the indication will be taught in conjunction with the associated aircraft system--for example, GTS FIRE, WHEELS, and L BAR lights. However, because the warning and caution annunciations cross multiple system boundaries and are critical to flight safety, they will be presented here.

Use the cockpit wall chart to identify the location of cockpit components throughout this lesson.

A. MASTER ALERT switch/light

?

The MASTER ALERT light provides what indication?

ANSWER: It alerts the aircrew to a warning or caution indication on the warning and caution advisory panels. It also flashes in conjunction with the illumination of the FIRE or L BAR warning lights.

1. Triggered by any warning or caution and also by FIRE and L BAR warning circuitry

2. Flashes amber to attract crew attention

3. Canceled when pressed by crew member

B. Warning light panel

Sg 2, fr 3
Fig 24: *Warning Light Panel*

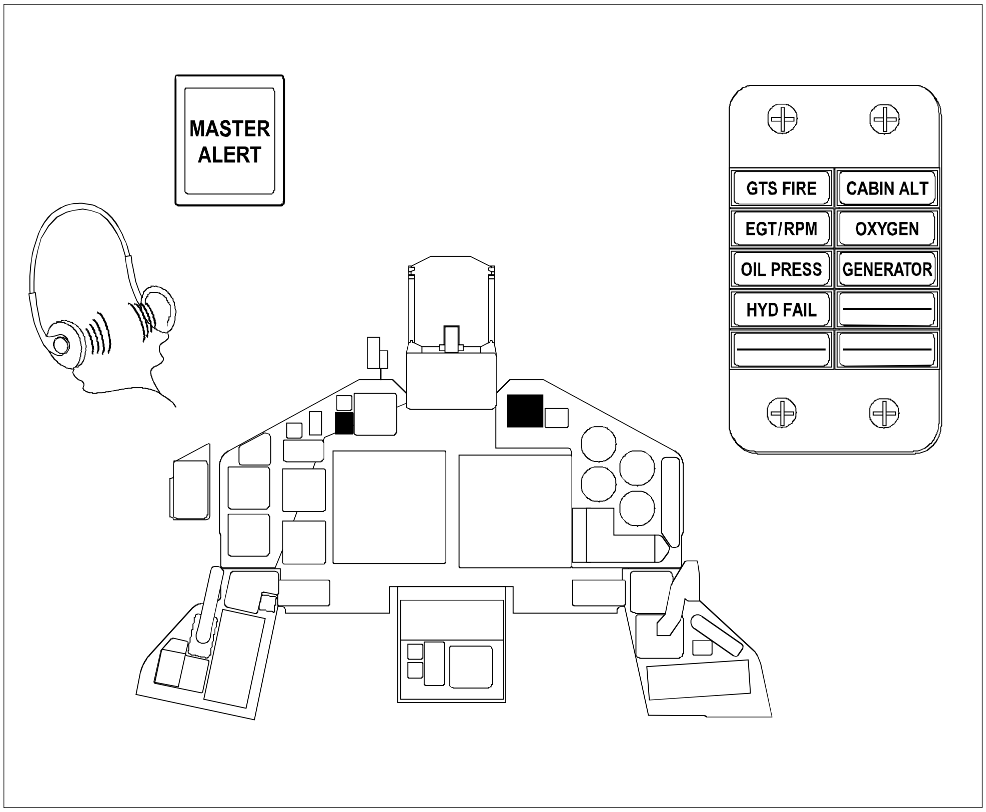


Figure 24: WARNING LIGHT PANEL

1. Red warning lights: alert crew to emergency condition requiring rapid response

C. Caution advisory light panel

Sg 2, fr 4
Fig 25: *Caution Advisory Light Panel*

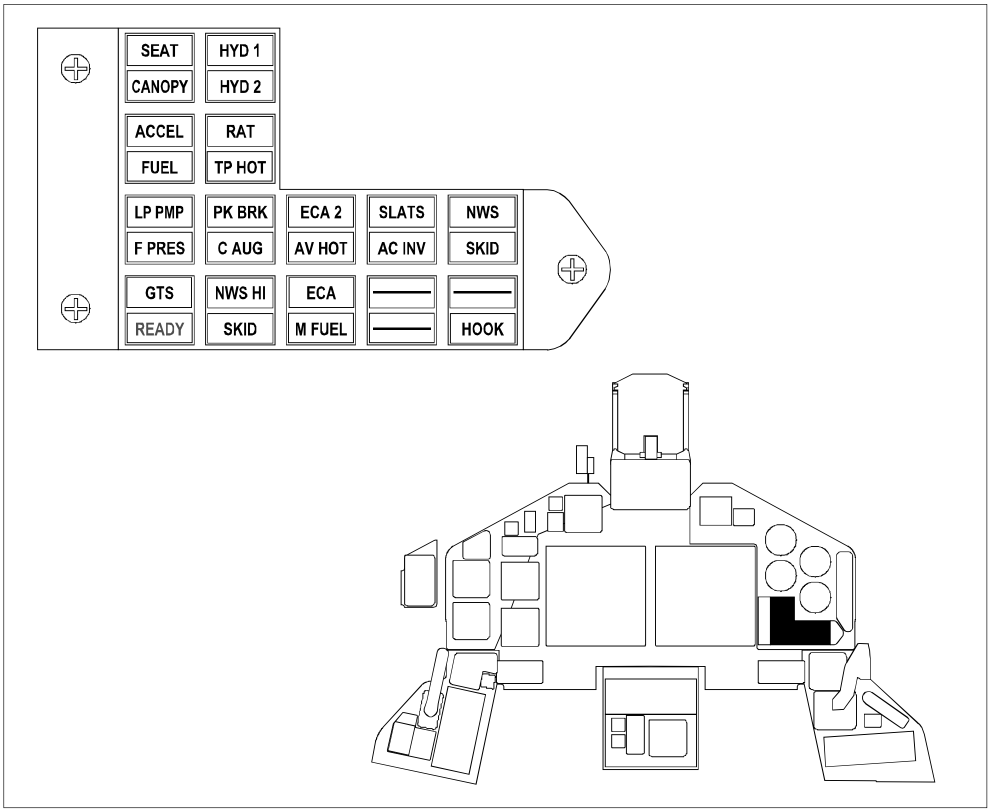


Figure 25: CAUTION ADVISORY LIGHT PANEL

1. Amber caution lights: alert crew to serious condition requiring monitoring and proper response

2. Caution lights remain illuminated until condition that caused the illumination no longer exists

3. Green advisory lights: provide system status requiring awareness and possible action

D. Centralized warning system master test

1. Master test switch used to test CWS lights and tones

   a. LIGHT TEST: illuminates all warning, caution, and advisory lights; also tests fire warning system

b. TONE TEST: sequentially generates four audio tones--warning, caution, wheels up, and weapons release

E. Intercom system (ICS) interface

1. Any warning condition detected by CWS causes ICS to generate warning tone in headset

   a. Two-tone warble

   b. Continues until MASTER ALERT switch/light is pressed

2. Any caution condition detected by CWS causes ICS to generate caution tone in headset

   a. Beeping monotone

   b. Lasts for 1 second, unless canceled first by either crew member

3. Additionally, stall warning, low altitude warning, and simulated gun firing tones are provided

Sg 10, fr 1
Review Menu

SUMMARY

The major systems of the T-45C consist of the following:

* Electrical system
* Engine system
* Fuel system
* Hydraulic (HYD) system
* Flaps/slats, speed brakes
* Landing gear system
* Brake system
* Anti-skid system
* Nose wheel steering (NWS) system
* Launch bar system
* Arresting hook system
* Flight control system
* Canopy and ejection system
* On-board oxygen generation system (OBOGS)
* Environmental control system (ECS)
* Flight instruments
* COMM/NAV instrument (CNI) system
* Display system
* Armament control system (ACS)
* Airborne data recording system
* Centralized warning system (CWS)

CONCLUSION

Fully understanding each of the T-45C systems is critical to safe and correct operation of the aircraft.

LECTURE GUIDE

COURSE/STAGE: TS, ADV & IUT Engineering

LESSON TITLE: Electrical System

LESSON IDENTIFIER: T-45C TS, ADV & IUT ENG-02

LEARNING ENVIRONMENT: Classroom

ALLOTTED LESSON TIME: 1.3 hr

TRAINING AIDS:

* Figures

Fig 1: Electrical System Block Diagram
Fig 2: Electrical System Block Diagram -- AC Power Relays Removed
Fig 3: Ground Power Panel
Fig 4: Fwd and Aft PWR Panels
Fig 5: Warning and Caution Advisory Panel Indications
Fig 6: Exterior Light Locations
Fig 7: Interior/Exterior Light Controls
Fig 8: Electrical Load Distribution

STUDY RESOURCES:

* T-45C NATOPS Flight Manual, A1-T45AC-NFM-000

LESSON PREPARATION:

Read:
* Part I, Chapter 2.3, “Electrical System,” T-45C NATOPS Flight Manual, A1-T45AC-NFM-000

REINFORCEMENT: N/A

EXAMINATION:

Student is required to read electrical system paragraphs in the NATOPS Flight Manual, receive classroom instruction, and complete assigned CAI lesson(s). The student shall demonstrate knowledge by completing, from memory with 80% accuracy, true/false and multiple choice block examinations. The objectives in this lesson will be tested in either Engineering 29X or Engineering 30X.

LESSON OBJECTIVES

1.4.4.3.1
Recall major components of the electrical system

1.4.4.2.1
Recall operating characteristics of the electrical system

1.4.4.3
Recall function, purpose, and location of electrical system controls, switches, and indicators

1.4.4.2
Recall interfaces between the electrical system and other a/c systems

MOTIVATION

You must understand the aircraft electrical system and its interfaces with other systems to operate the T-45C safely and efficiently.

OVERVIEW

This lesson will build on the knowledge of basic electrical system operations you gained during previous training.

In this lesson we will be studying:

* Major electrical system components and operating characteristics
* Function, purpose, and location of electrical system controls, switches, and indicators
* Aircraft lighting system
* Interfaces between the electrical and other T-45C systems

REFRESHER

* The T-45C electrical system functions much the same as the T-34 electrical system.

PRESENTATION

Sg 1, fr 2
Lesson Organization

ELECTRICAL SYSTEM

* Major component identification
* Operational characteristics
* Aircraft lighting system
* Aircraft interfaces

I. Electrical system major component identification **1.4.4.3.1**

Sg 1, fr 3 (9 Overlays)
Fig 1: *Electrical System Block Diagram*

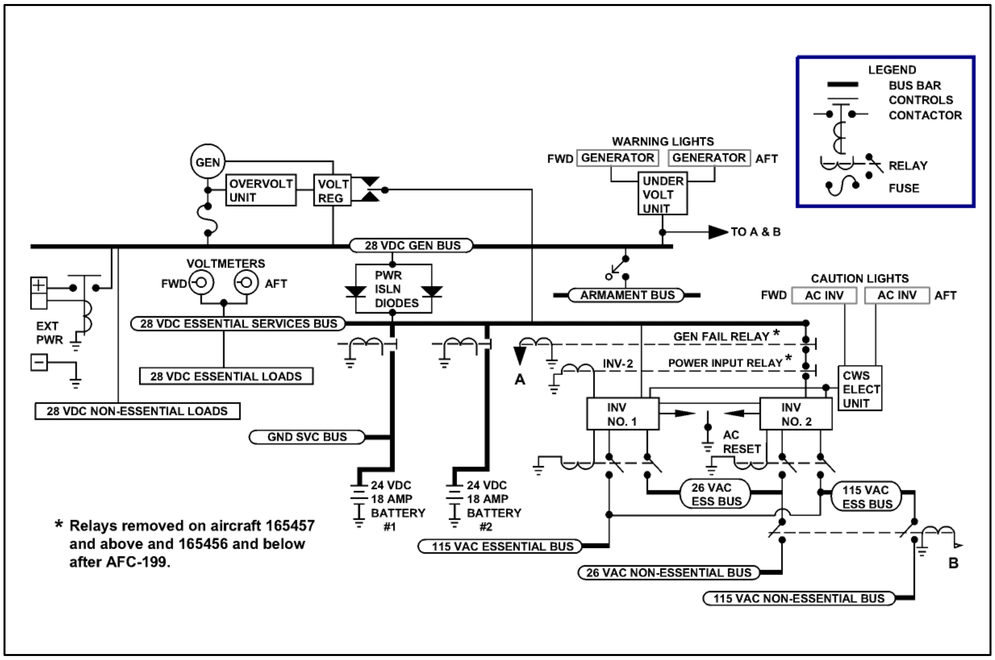


Figure 1: ELECTRICAL SYSTEM BLOCK DIAGRAM

A. Power generation and control

Overlay 1
Generator

1. Generator

   a. Location: below engine, mounted on engine accessory gearbox

   b. Description

      (1) Functional: produces aircraft main source of electrical power

      (2) Physical: 28 VDC, 9 KW brushless generator

Overlay 2
Batteries

2. Batteries

   a. Location: main equipment bay, mounted to lower sections of frame 10, accessed through forward equipment access door

b. Description

(1) Functional

(a) Provide DC power to start aircraft

(b) Provide emergency power if generator fails

(c) If generator will not reset, two good batteries will give power for 27 minutes. With only one good battery, power will only be available for 12 minutes.

(2) Physical: two sealed lead/acid 24 VDC, 18 AH batteries

Overlay 3
Inverters

3. Inverters

a. Location: mounted on aft equipment access door

b. Description

(1) Functional: convert aircraft 28 VDC to 115 VAC and 26 VAC, 400 Hz, single-phase power

(2) Physical: two identical 500 W inverters

c. Generator Fail and Inverter No. 2 power input relays removed on aircraft 165457 and up and on aircraft 165456 and below with AFC 199 incorporated

Overlay 4
Voltage Regulator

B. Power control

1. Voltage regulator

a. Location: under floor equipment compartment, right side of aircraft

b. Description: controls generator output to match electrical loads

2. Overvoltage unit

Overlay 5
Overvoltage Unit

a. Location: under floor equipment compartment, right side of aircraft

b. Description: monitors generator voltage and takes generator off-line if output voltage exceeds 30.2 VDC

3. Undervoltage unit

Overlay 6
Undervoltage Unit

a. Location: under floor equipment compartment, right side of aircraft

b. Description

(1) At 25 volts or less deenergizes, illuminating the GENERATOR warning light

(a) On aircraft 165456 and below without AFC 199

(i) Activates relay disabling one inverter illuminating AC INV caution light

(ii) Activates relay disconnecting non-essential AC bus

(b) On aircraft 165457 and up and on aircraft 165456 and below with AFC 199 incorporated

(i) Both inverters remain on-line and AC INV caution does not illuminate

(ii) Activates relay disconnecting non-essential AC bus

(2) Functional: monitors voltage on generator bus

(3) Physical: consists of transistorized voltage-sensing, time-delay circuit and changeover relay

PROGRESS CHECK

Question 1 — 1.4.4.3.1
In the event of a generator failure, approximately how long will the batteries supply power?

ANSWER: 27 minutes with two good batteries, 12 minutes with one battery

Overlay 7
Fuse

C. Power protection

1. Fuse

a. Location: forward end of engine bay

b. Description: connects generator to 28 VDC generator bus and provides 300 amp generator protection

Overlay 8
Buses

2. Buses and circuit breakers

a. Location: under floor equipment compartment, accessed through forward equipment access door

NOTE: Because all breakers are on the underside of the aircraft, the aircrew cannot reset them during flight.

b. Description

(1) Three essential buses (two AC and one DC) powered by battery power if generator fails—e.g., IFF, fire detection, warning and caution advisory panels, and UHF/VHF #1

(2) Three non-essential buses (two AC and one DC) drop off the line if the generator fails

(3) Push-pull thermal circuit breakers of various amperage levels provide

(a) Bus connection for aircraft electrical systems

(b) Isolation/protection for their respective functions in the event of electrical failures

PROGRESS CHECK

Question 2 — 1.4.4.3.1
Which electrical component monitors generator voltage and takes the generator off-line if output voltage exceeds 30.2 VDC?

ANSWER: Overvoltage unit

D. Power distribution relays and contactors

Overlay 9
Relays and Contactors

1. Location: under floor equipment compartment

2. Description: remote logic controlled relays

a. AC isolation relays disconnect non-essential services 115 and 26 VAC buses from 115 and 26 VAC essential buses when generator goes off-line

Sg 1, fr 13
Fig 2: *Electrical System Block Diagram -- AC Power Relays Removed*

b. Generator Fail and Inverter No. 2 Power Input Relay

(1) On aircraft 165456 and below without AFC 199 -- relays disconnect one inverter illuminating the AC INV caution light when the generator fails

(2) On aircraft 165457 and up and on aircraft 165456 and below with AFC 199 incorporated

(a) Relays are removed, and both inverters are wired directly to the 28 VDC essential services bus

(b) Both inverters remain on-line and AC INV caution does not illuminate with a generator failure

c. Three contactors provide bus connection to battery and external power

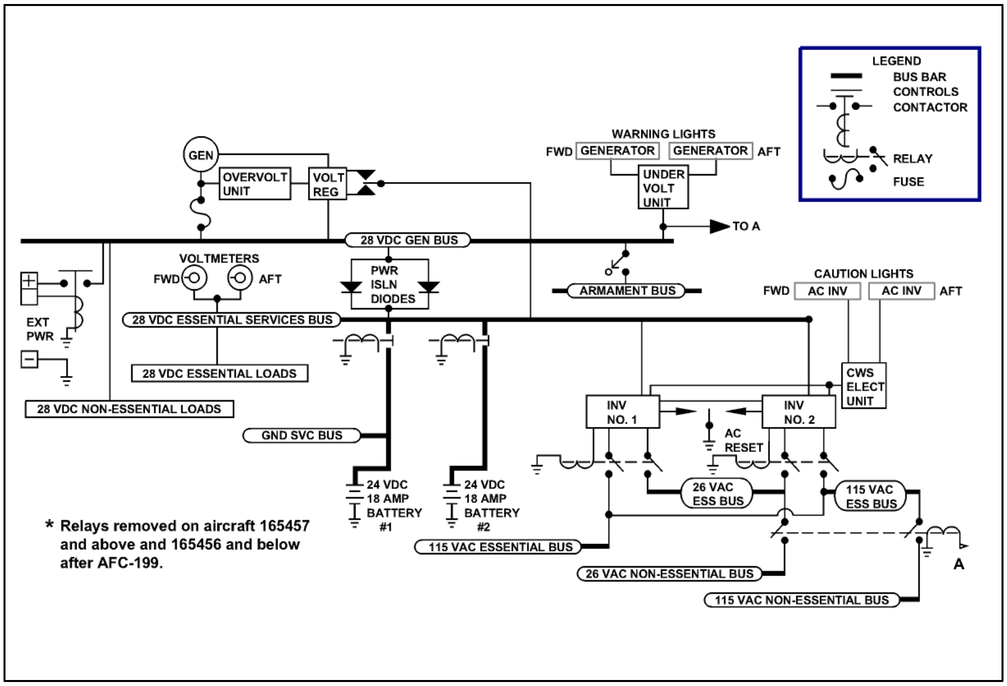


Figure 2: ELECTRICAL SYSTEM BLOCK DIAGRAM -- AC POWER RELAYS REMOVED

II. Electrical system operational characteristics **1.4.4.2.1, 1.4.4.3**

A. DC power system: consists of two batteries, generator, voltage regulator, overvoltage unit, two 28 VDC buses, and undervoltage unit

1. Power generation

a. Main electrical power supplied by 28 VDC brushless generator

(1) During ground starts the GEN WARNING light will extinguish when a suitable DC output is obtained 25-25.2 VDC (at approximately 45% RPM)

b. As engine rpm or electrical loads change, the voltage regulator controls output voltage to 28.2-29.2 VDC by adjusting generator excitation voltage

c. Overvoltage protection unit monitors generator output and prevents voltage from exceeding 30.2 VDC by shutting down generator

d. If generator goes off-line

(1) MASTER ALERT light flashes

(2) GENERATOR warning light on warning panel illuminates

(3) Warning tone sounds

NOTE: The MASTER ALERT light and warning tone may be canceled by pressing the MASTER ALERT light.

Sg 2, fr 2
Lesson Organization

ELECTRICAL SYSTEM

* Major component identification
* Operational characteristics
* Aircraft lighting system
* Aircraft interfaces

Sg 2, fr 3 *(7 Overlays)*
Fig 1: *Electrical System Block Diagram*

Overlay 1
Generator

Overlay 2
Voltage Regulator

Overlay 3
Overvoltage Unit

Overlay 4
Generator Bus

Overlay 5
28 VDC Essential Services Bus

2. Distribution

   a. 28 VDC generator bus supplies non-essential services and is distributed by three circuit breaker panels

   b. 28 VDC essential services bus links to 28 VDC generator bus through two power isolation diodes

      (1) Power isolation diodes isolate essential services bus from generator bus if generator fails

      (2) 28 VDC essential services bus power is distributed by a single circuit breaker panel

Overlay 6
Batteries

      (3) Charge batteries

3. Battery operations

   a. Two 24 volt, 18 AH lead acid batteries supply power to essential services bus

      (1) Provide DC power during engine start

      (2) If generator fails, supply emergency voltage to 28 VDC essential services bus

   b. Charged as long as generator is on-line and batteries are connected to essential services bus

Overlay 7
Ground Services Bus

   c. Battery #1 supplies power to ground services bus

      (1) Provides DC power during refuel/defuel

Sg 2, fr 10
(3 Overlays)
Fig 1: *Electrical System Block Diagram*

B. AC power system: consists of two identical 26/115 VAC, 400 Hz single phase inverters, two 26 VAC buses, and two 115 VAC buses

1. Power generation

a. 26 and 115 VAC power developed by two identical inverters powered by 28 VDC essential services bus

Overlay 1
Inverters

b. Inverters are internally protected for input or output faults

(1) Automatically reset when input fault clears

(2) Require manual reset for output fault

Overlay 2
26/115 VAC Essential Services Buses

Overlay 3
Non-Essential Buses

2. Distribution

a. 26 and 115 VAC essential buses provide distribution for AC essential services

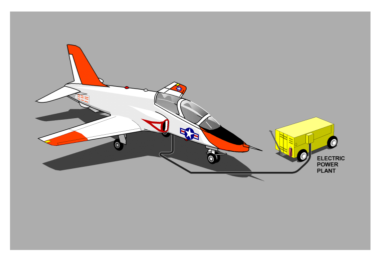
b. 26 and 115 VAC non-essential buses provide distribution for non-essential services

c. When generator is off-line, 26 and 115 VAC non-essential buses are taken off-line

d. Two 6 VAC buses provide distribution from 115 VAC essential and non-essential buses to wing navigation and formation lights

C. Ground power system

Sg 2, fr 14
External Electrical Connections



1. Description

a. External 28 VDC power may be connected to aircraft for

(1) Battery charging

(2) Ground maintenance

Sg 2, fr 14, p 1
Fig 3: *Ground Power Panel*

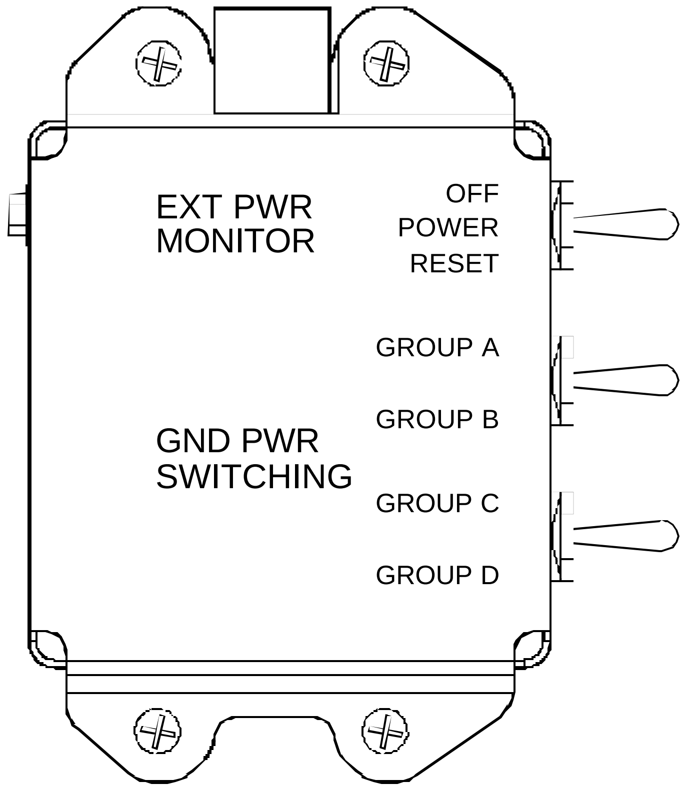


Figure 3: GROUND POWER PANEL

b. Ground power panel

(1) External power monitor sw

(2) Ground power sw #1 and #2

NOTE: Ground power switches used for maintenance enabling additional systems to come on line.

NOTE: Starting the GTS with external power is PROHIBITED.

c. EXTERNAL POWER RECEPTACLE access door located on right side of fuselage just under intake

2. Normal operations: external power contactor routes external power to 28 VDC generator bus and disables centralized warning system (CWS) (when fuel shutoff handle is pulled) with exception of

   a. Warning tone trigger

   b. MASTER ALERT

   c. FIRE

   d. GTS FIRE

D. Fault protection analysis

1. Generator failure: any malfunction may be described as either an overvoltage or undervoltage condition

   a. Overvoltage: if the generator voltage exceeds 30.2 VDC, the overvoltage relay takes the generator off-line and all voltage is lost to the generator bus resulting in the following:

      (1) Disconnects 26 and 115 VAC non-essential buses from inverters, removing all non-essential AC loads

         (a) HUD and right MFD in both cockpits are disconnected

         (b) Left MFD in both cockpits revert to ADI display

         NOTE: After 2 minutes, a relay drops power to the left MFD in both cockpit, DEU, SADS, and VCR/CEU.

      (2) On aircraft 65456 and below without AFC 199 -- one inverter disconnected to conserve battery power, illuminating AC INV caution light

Sg 2, fr 15
(6 Overlays)
Fig 1: *Electrical System Block Diagram*

Overlay 1
Undervoltage Condition

(3) On aircraft 165457 and up and on aircraft 165456 and below with AFC 199 incorporated -- both inverters remain on-line, AC INV caution does not illuminate

(4) Signal CWS

(a) MASTER ALERT flashes

(b) Warning tone sounds

(c) GENERATOR warning light on warning panel illuminates

(d) AC INV caution light on caution advisory panel illuminates only on aircraft 165456 and below without AFC 199

(e) C AUG caution light on caution advisory panel illuminates

(f) F PRES caution light illuminates after 30 sec

Overlay 2
Overvoltage Condition

b. Undervoltage: If the generator output falls below 25 VDC for more than 1.5 seconds, the undervoltage sensing unit will detect the same and illuminate the generator warning light and drop the non-essential AC. The generator IS NOT taken off-line and may continue to operate in an under-voltage condition. The indications will be the same as those stated above after an overvoltage or when generator fails with the following exceptions:

(1) HUD and right MFD in both cockpits will continue to function until the batteries can no longer sustain operations

(2) Left MFD in both cockpits will not be affected

(3) The 2-minute relay does not come into play

(4) The C AUG caution light does not illuminate

(5) The F PRES caution light does not illuminate

NOTE: If the generator continues to operate at less voltage than the batteries, then the battery voltage will drop until it matches the generator voltage.

c. Generator reset: may be attempted by generator switch (RESET) and generator brought back on-line if failure is transient

2. Battery failure: battery voltage of approximately 17 VDC is required to reset the generator should it be tripped off-line

Overlay 3
Battery Failure

3. Undervoltage unit failure (likely caused by a circuit breaker failure)

Overlay 4
Undervoltage Unit Failure

a. No indication of failure on CWS

b. 26 and 115 VAC non-essential buses will not be shed

c. Indications of undervoltage sensing unit failure

(1) BATTERY VOLTS meter on PWR panel reads less than 25 VDC, with no generator failure light

NOTE: With an undervoltage sensing unit failure, the generator will continue to operate when operating in an undervoltage condition unless manually secured. An undervoltage condition of less than normal battery voltage will discharge the batteries.

(2) AC instruments become erratic or fail as inverters lose adequate DC voltage to operate

NOTE: inverter failure will occur at voltages of 21.5 VDC or less and insufficient DC voltage will preclude inverter reset.

Overlay 5
Single Inverter Failure

4. Single inverter failure

   a. AC INV caution light illuminates (along with MASTER ALERT and caution tone)

   b. GENERATOR warning light remains off

   c. Non-essential AC services are lost

Overlay 6
Double Inverter Failure

5. Double inverter failure: indications same as single inverter loss, except all AC services are lost

PROGRESS CHECK

Question 3 — 1.4.4.2.1, 1.4.4.3
What are the indications of an undervoltage unit failure?

ANSWER: None, unless the generator actually begins to produce low voltage. The inverters will fail when DC voltage falls below 21.5 volts.

Question 4 — 1.4.4.2.1, 1.4.4.3
What are the indications of a single inverter failure?

ANSWER: The AC INV caution light illuminates with loss of the non-essential AC services.

E. Power system controls, switches, and indicators

1. PWR Panel

a. Location: right console, both cockpits

b. Function

(1) Voltmeter (BATTERY VOLTS): monitors 28 VDC essential services bus and provides

(a) Battery voltage status indication when generator is off-line or when starting aircraft

(b) Generator voltage with generator operating and on line

(2) Battery switches (BATT 1 and 2): control battery connection to 28 VDC essential services bus

Sg 2, fr 23, pg 1
Power Panel -- Forward Cockpit

Fig 4: *Power Panels*

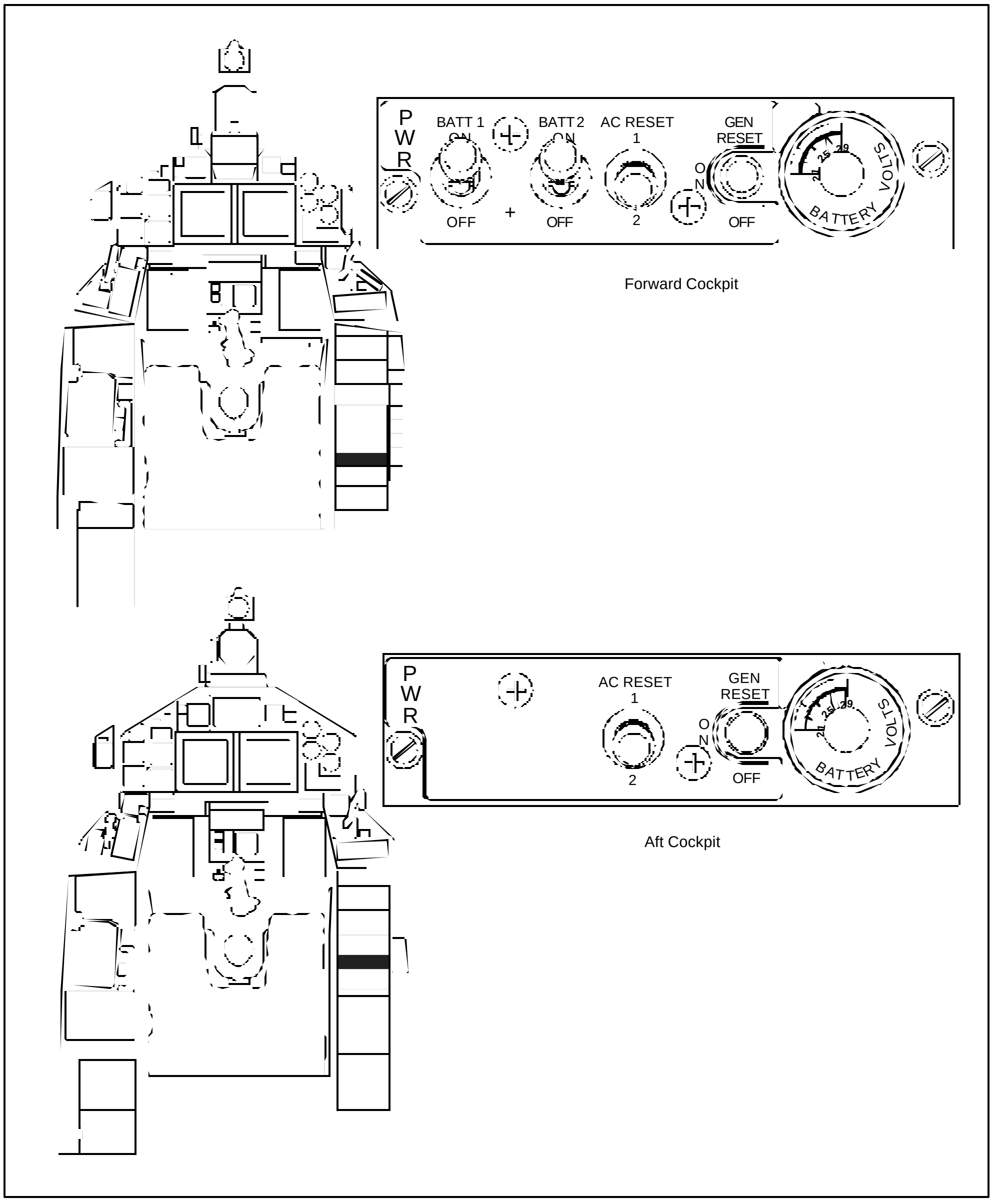


Figure 4: POWER PANELS

NOTE: Battery switches are not provided in the aft cockpit.

(3) AC RESET switch: spring loaded center-on, used to reset AC inverter No. 1 or AC inverter No. 2

(4) Generator (GEN) switch: OFF/ON/RESET positions allow control of generator

Sg 2, fr 23, pg 2
Power Panel -- Aft Cockpit

***Fig 4:** Power Panels*

2. Warning and caution advisory panels

Sg 2, fr 24
Fig 5: *Warning and Caution Advisory Panel Indications*

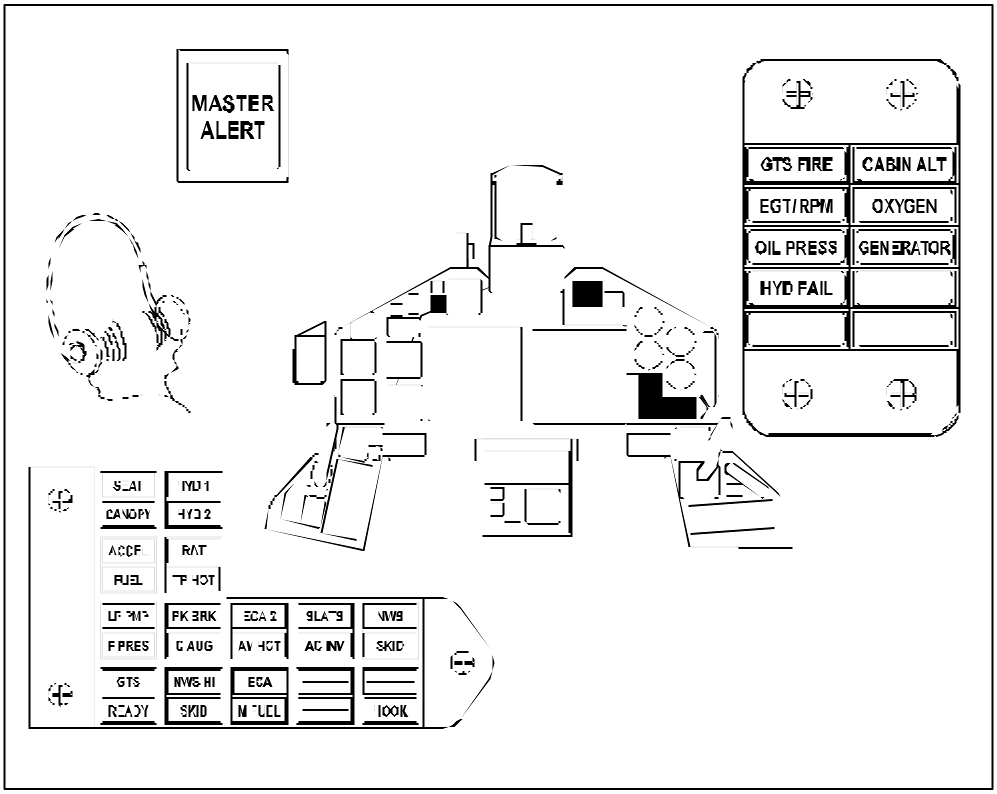


Figure 5: WARNING AND CAUTION ADVISORY PANEL INDICATIONS

a. Location: right side of instrument panel, both cockpits

b. Function

(1) GENERATOR warning light illuminates when generator is off-line

(2) AC INV caution light

(a) Illuminates if one or both inverters fail (ALL AIRCRAFT) or is tripped off-line by the Generator fail relay, aircraft 165456 and below without AFC 199

Sg 3, fr 2
Lesson Organization

ELECTRICAL SYSTEM

* Major component identification
* Operational characteristics
* Aircraft lighting system
* Aircraft interfaces

Sg 3, fr 3
Fig 6: *Exterior Light Locations*

III. Aircraft lighting system

A. Exterior lighting

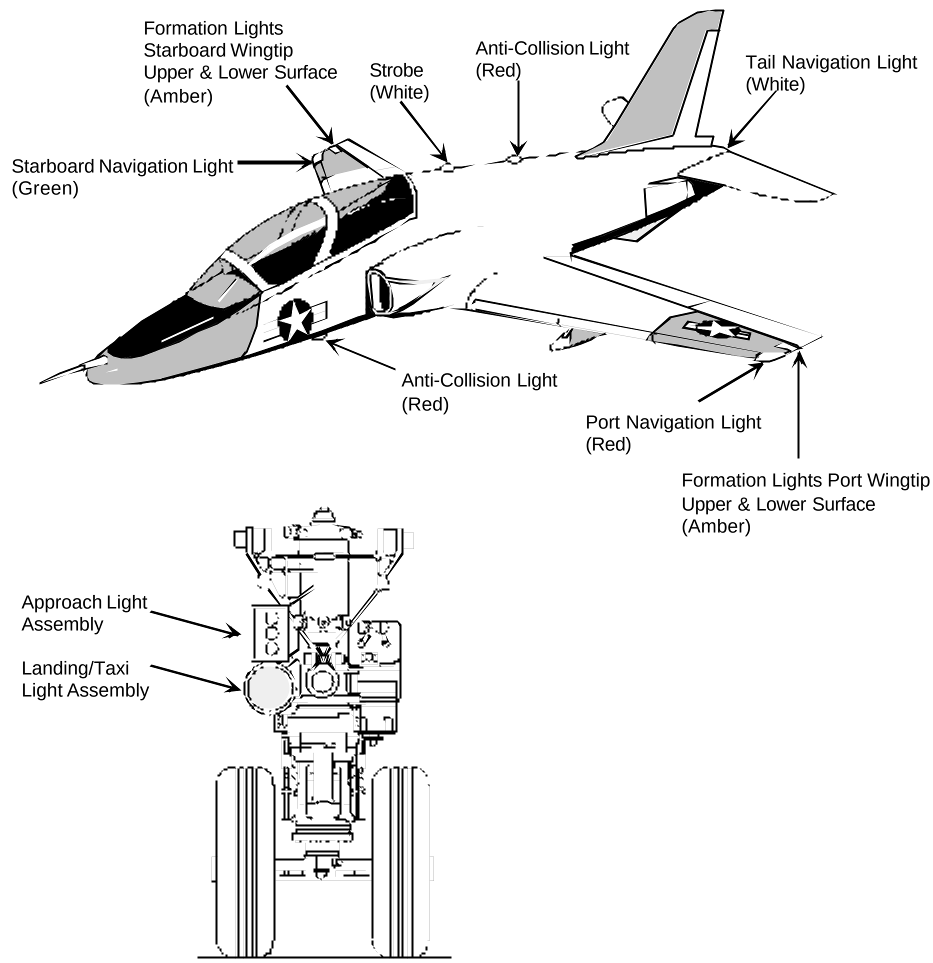


Figure 6: EXTERIOR LIGHT LOCATIONS

1. Navigation lights

a. Location

(1) Green on right wingtip

(2) Red on left wingtip

(3) White on tail

b. Powered by:

(1) Wing: 115 VAC essential services bus (stepped down to 6 VAC)

(2) Tail: 28 VDC essential services bus

c. Operate in either bright or dim in the following modes

(1) Steady

(2) Flashed (approximately 90 flashes per minute)

(3) Manually flashed (used as signal to deck crew or wingman)

2. Anti-collision lights

a. Location

(1) Red rotating beacon, rearward on center top fuselage

(2) Red rotating beacon, lower fuselage

(a) Gear up: on

(b) Gear down: off

(3) White high intensity strobe, center top fuselage

b. Powered by 28 VDC generator bus

3. Formation lights

a. Location: amber lights on upper and lower surface of each wingtip

b. Powered by 115 VAC non-essential bus (stepped down to 6 VAC)

Sg 3, fr 4
Exterior Light Controls

Fig 7: *Interior/ Exterior Light Controls*

c. Operate in bright or dim mode

4. Taxi/landing light

   a. Location: right side of nose landing gear strut

   b. Powered by 28 VDC generator bus

5. Controls/switches

   a. Navigation lights: controlled by four switches located in fwd cockpit

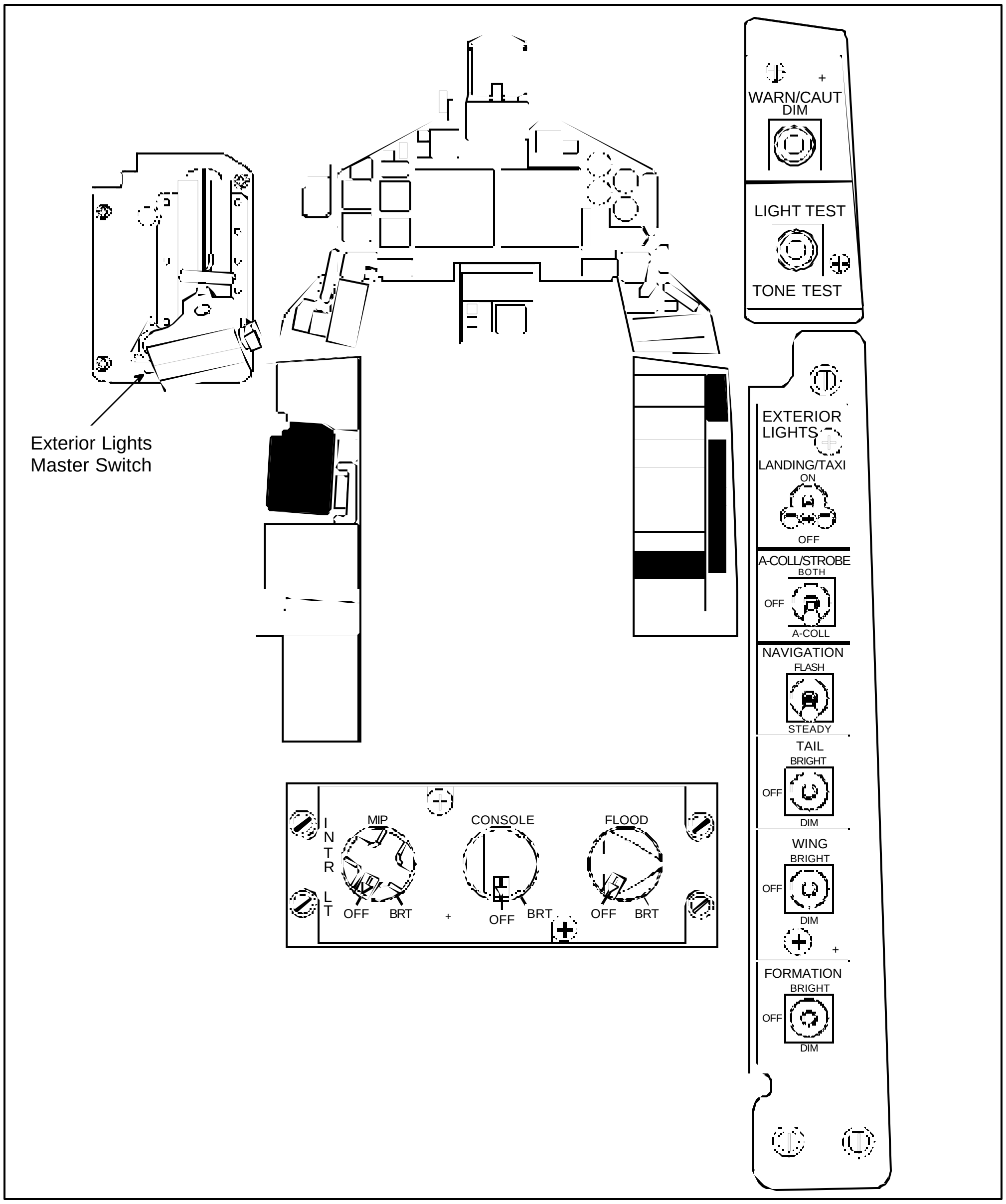


Figure 7: INTERIOR/EXTERIOR LIGHT CONTROLS

(1) WING LIGHTS and TAIL LIGHTS: BRIGHT/OFF/DIM switches, right console, control individual lights

(2) NAV LIGHTS: FLASH/STEADY switch, right console, controls select operation mode

(3) Exterior lights master switch, throttle handle, controls all navigation lights

b. Anti-collision lights: controlled by anti-collision (A-COLL/STROBE) light switch on right console, fwd cockpit

(1) In A-COLL position, upper and lower rotating beacons operate

(2) In A-COLL/STROBE both position, all anti-collision lights operate and strobe flashes approximately 90 times per minute

c. Formation lights: controlled by FORMATION (BRIGHT/OFF/DIM) switch on right console of fwd cockpit

d. Taxi/landing light: controlled by the LAND/TAXI (ON/OFF) switch on right console of fwd cockpit

B. Interior lighting

1. Description: general cockpit lighting and lighting of control units and indicators

Sg 3, fr 6 *Interior Light Controls*

Fig 7: *Interior/ Exterior Light Controls*

a. Left/right console, center panel and console strip lighting: powered by 28 VDC generator bus

b. Emergency lighting (single lamp in each flood strip and map lights): powered by 28 VDC essential services bus

2. Controls/switches

   a. Instruments, control panels/units, and light plates on the main instrument panel are powered from the 26 VAC non-essential bus

   b. Instrument, control panels/units, and light plates on the left and right consoles are powered from the 115 VAC non-essential bus

   c. Emergency lights are powered by the 28 VDC essential services bus and illuminate automatically

   d. Map reading lights are powered by the 28 VDC essential services bus and are available at all times the bus is powered. Map reading lights are independently controlled with a dedicated rheostat within each light

   e. When WARN/CAUT Dim Select switch is on, the intensity of the warning, caution, and advisory lights is automatically dimmed

   f. The MIP on/off switch is an integral part of the MIP rheostat

Sg 5, fr 2
Lesson Organization

ELECTRICAL SYSTEM

* Major component identification
* Operational characteristics
* Aircraft lighting system
* **Aircraft interfaces**

IV. Electrical system aircraft interfaces **1.4.4.2**

LESSON NOTES

Refer to Figure 8 for a replication of the Electrical Load Distribution list printed in NATOPS. Note that the 28 VDC Ground Services Bus is not shown. However, it is depicted in the NATOPS Electrical Distribution foldout.

28VDC - GENERATOR BUS			
AC Isolation Relay ADRS Total Air Temp Htr Pwr Aileron Trim Control Aileron Trim Position Indicator Angle-of-Attack Heat Anti-collison Lights Baro Altimeter, Stby	Bombs Release Cabin Pressure Control 2 Comm Control Power B DEP, Fwd Flood Lighting GTS Drain Valve Landing/Taxi light Master Arm MDL Power	MFDs, Right (Both Cockpits) OBOGS Heat Overvoltage Unit Reticle Light Rockets Release Rudder Trim Control Stabilator Position Indicator	Stabilator Trim Standby UHF/VHF 2 Undervoltage Sensing Voltage Regulator VOR/ILS Control Yaw Damper
28VDC - ESSENTIAL SERVICES BUS			
Accel/Bleed Valve Control Accel/Bleed Valve Indicator ADI, Standby ADRS Angle-of-Attack Indicator Annunciator Lights Anti-Skid Control Approach Idle Stop Arresting Hook Cabin Pressure Control 1 Cabin Pressure Warning Cabin Temperature Control Caution Warning System Comm Control Pwr A DC Power External Supply DC Power Generator Reset DC Power Voltmeters-DEU [2]	Ejection Enable Switch (IFF) Emergency Jettison (Wing Station Only) Emergency Lighting Emergency NLG Door Actuation Control Engine Bleed Valve Engine Control & EGT Indicator Pwr Engine Vibration and Pressure Monitor External Power Fire Detection Flaps Control (Emer) Flaps Control Main Flaps Position Indicator Fuel Boost Pump Inverters [1] Fuel Boost Pumps Control [1] Fuel Flow Indicator Fuel System Control Fuel System Low Level Warning	Fuel System Quantity Indicator Generator Off-Load Generator Undervoltage GINA GTS Fuel/Oil Pump HYD 1, 2, & Brake Transducer Hydraulic 2 Bypass IFF Control IFF RCVR/XMTR Ignitors Inverters Protection Landing Gear Control Landing Gear Selector Valve Launch Bar Manual Fuel Sys Bleed Valve Time Delay Manual Fuel System Control Master Start 1 & 2 Master Switch Batt 2 MFD, Left (Both Cockpits) [2]	Navigation Light, Tail Nose Wheel Steering OBOGS Monitor OBOGS Shutoff Valve Pitot Probe Heat Press To Test Ram Air Turbine Reset Rudder Pedal Shaker Motor SADS [2] Seat Position Slats Position Indicator Speedbrake Control Speedbrake Position Indication Stabilator Trim Main TACAN Throttle Proximity Switches Turn/Slip Indicator UHF/VHF 1 VCR/CEU [2] Weight-on-Wheels Control
115 VAC BUSES		**26 VAC BUSES**	
ESSENTIAL	**NON-ESSENTIAL**	**ESSENTIAL**	**NON-ESSENTIAL**
Annunciator Lights (Night) Emergency NLG Door Act (Pwr) GINA (Synchro. Signal)	DEU Cooling Fan Radar Altimeter	TACAN ADR	DEU VOR/ILS/MB Yaw Damper
6 VAC BUSES		**5 VAC NON-ESSENTIAL BUS**	
ESSENTIAL	**NON-ESSENTIAL**	MIP Cockpit Lights	
NAV Lights, Wing	Formation Lights		
28 VAC NON-ESSENTIAL BUS			
Console Lights			

LEGEND

[1] Operate for 30 seconds after loss of generator bus.
[2] Operate for 2 minutes after loss of generator bus.

Figure 8: ELECTRICAL LOAD DISTRIBUTION

A. 28 VDC generator bus: equipment powered

1. Cockpit flood lights

2. LDN/TAXI light

3. ANTI-COLL/STROBE lights

Sg 5, fr 4
Electrical Load Distribution--Part 1

Fig 8: Electrical Load Distribution

4. HUD

5. Right Hand-Multifunction Display (MFD)

6. VOR/ILS control

B. 28 VDC ground services bus: equipment powered

1. Refuel/Defuel systems

2. Refuel Precheck system

3. Master Switch for battery #1 power

NOTE: This switch is accessible, only when the refueling access door on the outside of the left engine inlet is opened (panel number 311EL). It is operated by a three-position switch in the upper part of the compartment, marked FLIGHT, REFUEL, DEFUEL. When that door is secured shut, a probe on the door holds the switch in the FLIGHT position, which disengages the Refuel/Defuel systems and the Master Switch for battery #1 power.

Sg 5, fr 4
Electrical Load Distribution--Part 2

28 VDC ESSENTIAL SERVICES BUS		
Accel/Bleed Valve Control	Engine Vibration and Pressure Monitor	Manual Fuel Sys Bleed Valve Time Delay
Accel/Bleed Valve Indicator	External Power	Manual Fuel System Control
ADI, Standby	Fire Detection	Master Start 1 & 2
ADRS	Flaps Control (Emer)	Master Switch Batt 2
Angle-of Attack Indicator	Flaps Control Main	MFD, Left (Both Cockpits) 2
Annunciator Lights	Flaps Position Indicator	Navigation Light, Tail
Anti-Skid Control	Fuel Boost Pump Inverters 1	Nose Wheel Steering
Approach Idle Stop	Fuel Boost Pumps Control 1	OBOGS Monitor
Arresting Hook	Fuel Flow Indicator	OBOGS Shutoff Valve
Cabin Pressure Control 1	Fuel System Control	Pitot Probe Heat
Cabin Pressure Warning	Fuel System Low Level Warning	Press To Test
Cabin Temperature Control	Fuel System Quantity Indicator	Ram Air Turbine Reset
Caution Warning System	Generator Off-Load	Rudder Pedal Shaker Motor
Comm Control Pwr A	Generator Undervoltage	SADS 2
DC Power External Supply	GINA	Seat Position
DC Power Generator Reset	GTS Fuel/Oil Pump	Slats Position Indicator
DC Power Voltmeters	HYD 1, 2 & Brake Transducer	Speedbrake Control
DEU 2	Hydraulic 2 Bypass	Speedbrake Position Indication
Ejection Enable Switch (IFF)	IFF Control	Stabilator Trim Main
Emergency Jettison (Wing Station Only)	IFF RCVR/XMTR	TACAN
Emergency Lighting	Ignitors	Throttle Proximity Switches
Emergency NLG Door Actuation Control	Inverters Protection	Turn/Slip Indicator
Engine Bleed Valve	Landing Gear Control	UHF/VHF 1
Engine Control & EGT Indctr Pwr	Landing Gear Selector Valve	VCR/CEU 2
	Launch Bar	Weight-on-Wheels Control

LEGEND: 1 Operate for 30 seconds after loss of generator bus. 2 Operate for 2 minutes after loss of generator bus.

C. 28 VDC essential services bus: equipment powered

1. EMERG lighting

2. NAV lights - TAIL

3. Display Electronics Unit (DEU) (for 2 minutes)

4. Left Hand-Multifunction Display (MFD) (for 2 minutes)

5. TACAN

D. 115 VAC essential bus: equipment powered

1. GPS/Inertial Navigation Assembly (GINA)

2. Warning/caution/advisory dimming (14/10 VAC)

3. Emergency NLG door actuator

E. 115 VAC non-essential bus: equipment powered

1. Display Electronics Unit (DEU) cooling fan

2. Radar altimeter

F. 26 VAC essential bus: equipment powered

1. Airborne Data Recorder

2. TACAN-Azimith computer

G. 26 VAC non-essential bus: equipment powered

1. DEU

2. VOR/ILS/MB

3. Yaw damper

H. 28 VAC essential bus - left and right console lights

I. 6 VAC essential bus - NAV lights (wing)

J. 6 VAC non-essential bus - Formation lights

K. 5 VAC non-essential bus - Main instrument panel lights

> ? **What should the voltmeter read with both batteries fully charged?**
>
> ANSWER: A minimum of 24 volts.

Sg 5, fr 4
Electrical Load Distribution--Part 3

Fig 8: *Electrical Load Distribution*

115 VAC BUSES		28 VAC NON-ESSENTIAL BUS
ESSENTIAL	NON-ESSENTIAL	
Annunciator Lights (Night) Emergency NLG Door Act (Pwr) GINA (Synchro. Signal)	DEU Cooling Fan Radar Altimeter	Console Lights
26 VAC BUSES		5 VAC NON-ESSENTIAL BUS
ESSENTIAL	NON-ESSENTIAL	
TACAN ADR	DEU VOR / ILS / MB Yaw Damper	MIP Cockpit Lights
6 VAC BUSES		
ESSENTIAL	NON-ESSENTIAL	
NAV Lights, Wing	Formation Lights	

Sg 10, fr 2
Review Menu

SUMMARY

This lesson focused on the following topics:

* Major components and operating characteristics of the T-45C electrical system
* Function, purpose, and location of the T-45C electrical system controls, switches, and indicators
* Aircraft lighting system
* Interfaces between the electrical and other T-45C systems

CONCLUSION

The electrical system is one of the most vital systems on any aircraft you will fly. Knowing how to operate the system properly and to analyze malfunctions is critical to the safety of your aircraft, your fellow crew members, and yourself.

LESSON GUIDE

COURSE/STAGE: TS, ADV & IUT Engineering

LESSON TITLE: Electrical System Malfunctions

LESSON IDENTIFIER: T-45C TS, ADV & IUT ENG-03

LEARNING ENVIRONMENT: CAI

ALLOTTED LESSON TIME: .7 hr

TRAINING AIDS:

* Figures
  Fig 1: Electrical System Diagram
  Fig 2: AC Inverter Failure
  Fig 3: Undervoltage Condition
  Fig 4: Generator Failure with Low Battery Voltage
  Fig 5: Electrical Load Distribution

STUDY RESOURCES:

* T-45C NATOPS Flight Manual, A1-T45AC-NFM-000
* T-45C NATOPS Pilot's Pocket Checklist, A1-T45AC-NFM-500

LESSON PREPARATION:

Read:
* Part I, Chapter 2, "Electrical System" and "Lighting Systems," T-45C NATOPS Flight Manual, A1-T45AC-NFM-000
* Part V dealing with electrical system malfunctions, T-45C NATOPS Flight Manual, A1-T45AC-NFM-000

Review:
* Lesson Guide for Eng-02, "Electrical System"

REINFORCEMENT: N/A

LESSON EXAMINATION:

Student is required to read electrical system paragraphs in the NATOPS Flight Manual, receive classroom instruction, and complete assigned CAI lesson(s). The student shall demonstrate knowledge by completing, from memory with 80% accuracy, true/false and multiple choice block examinations. The objectives in this lesson will be tested in either Engineering 29X or Engineering 30X.

LESSON OBJECTIVES

1.8.1.3.1.2.1
Identify indications of single inverter failure

1.8.1.3.1.3.1
Identify indications of double inverter failure

1.8.1.3.4.1
Identify indications of undervoltage condition

1.8.1.3.1.1.1
Identify indications of generator failure

1.8.1.3.1.4.1
Identify indications of total electrical failure

MOTIVATION

Picture yourself flying Mach .67 in the "goo" at 2208 hours. You're thinking about what a good flight you've had so far when suddenly you experience a total electrical failure.

As a Naval aviator, you must be able to identify an electrical system malfunction and quickly use your knowledge of the system to correct the situation and decide whether to complete or abort the flight. In addition, the more accurately you can describe a malfunction, the shorter the maintenance downtime will be.

This lesson shows you how to identify several malfunctions that could occur in the electrical system.

Keep in mind that, although these malfunctions are presented separately, one malfunction might well cause another. Likewise, multiple malfunctions could occur at the same time; in the simulator, they certainly will. Later in the curriculum, you'll learn the precise emergency procedures for each of the malfunctions described in this lesson.

OVERVIEW

The goal of this lesson is to sharpen your decision making in response to an electrical system malfunction. Being able to make the appropriate decisions should a malfunction occur may extend your flight and your life!

This lesson presents indications of the following electrical system malfunctions:

* AC inverter failure (single and double)
* Undervoltage Condition
* Generator failure
* Total electrical failure

REFRESHER

Recall:

* Normal operation of the electrical system from Eng-02

* Electrical malfunction CWS indicators include the MASTER ALERT light, GENERATOR warning light, and AC INV caution light

* Location and function of electrical system indicators and switches from Eng-02

Fig 1: *Electrical System Diagram*

PRESENTATION

I. Single/double AC inverter failure **1.8.1.3.1.2.1, 1.8.1.3.1.3.1**

NOTE: AC inverter malfunctions may be transient in nature. If the input or output of an inverter is out of tolerance, the defective inverter will go off-line, and the other inverter will take control of the inverter functions. If the defective inverter can be reset, its failure is considered to be transient.

A. Single inverter failure

1. Indications

a. MASTER ALERT flashes

b. Caution tone sounds

c. AC INV caution light illuminates

NOTE: The AC inverters are redundant (one backs up the other), the loss of one inverter will not affect the operation of essential AC services.

Fig 2: *AC Inverter Failure*

2. Verifications: loss of nonessential AC services

3. Effects on flight safety

   a. Instrument flight and navigational capabilities reduced by loss of nonessential AC equipment:

      (1) Radar altimeter

      (2) VOR/ILS/MB

   b. Instrument approaches limited to TACAN or radar approaches

B. Double inverter failure

1. Indications

   a. MASTER ALERT flashes

   b. Caution tone sounds

   c. AC INV caution light illuminates

2. Verifications: loss of all AC services (DC services will remain available)

3. Effects on flight safety

   a. If reset of AC inverter not possible, TACAN azimuth, and GINA will be lost due to loss of VAC

   b. Requires use of standby instruments for IMC

      NOTE: The standby attitude indicator does not depend on aircraft AC inverters. It will continue to operate with 28 VDC supplied from the 28 VDC essential services bus.

   c. Maintain VMC if possible and land as soon as practicable

   d. Normal instrument approaches impossible--limited to radar approaches

II. Undervoltage condition **1.8.1.3.4.1**

Fig 3: Undervoltage Condition Failure

A. Indications

1. MASTER ALERT flashes

2. Caution and warning tones sound

3. GENERATOR warning light illuminates

4. AC INV caution light illuminates -- aircraft 165456 and lower before AFC 199 incorporated

5. C AUG caution light illuminates

6. F PRES caution light illuminates

NOTE: There is a 30-sec delay in the illumination of the F PRES caution light after the loss of the Generator Bus.

B. Verifications: BATTERY VOLTS meter reads 25 VDC or less

C. Effects on flight and safety: With the generator no longer on line, the nonessential AC buses have automatically shed and electrical power is limited to battery power voltage available. Functional equipment on the essential buses are limited to required operational voltage and may fail at any time even though battery voltage is still indicated on the voltmeter.

NOTE: A failure of the undervoltage sensing unit itself will remove the ability of the electrical system to detect a low voltage condition on the generator bus; therefore the GENERATOR warning light will not illuminate if the generator voltage drops below 25 VDC. The first indication of an undervoltage sensing unit failure would be to have observed voltage of less than 25 VDC without the GENERATOR warning light being illuminated. When this happens the nonessential AC load is retained, thereby depleting the battery voltage at a faster rate. Once the battery voltage is below approximately 21.5 VDC the inverters will start to fail. While the voltage is between 21.5 and 24 volts, it would be best to secure the generator to shed the nonessential AC load which will extend the battery life.

Fig 4: Generator Failure with Low Battery Voltage

III. Generator failure **1.8.1.3.1.1.1**

A. Indications

1. MASTER ALERT flashes

2. Caution and warning tones sound

3. GENERATOR warning light illuminates

4. AC INV caution light will illuminate -- on aircraft165456 and lower before AFC 199 incorporated

5. C AUG caution light on caution advisory panel illuminates

6. F PRES caution light illuminates

   NOTE: There is a 30-sec delay in the illumination of the F PRES caution light after the loss of the Generator Bus.

7. Right MFD disabled

Fig 5: Electrical Load Distribution

B. Verifications

NOTE: The Electrical Load Distribution table shown in Figure 5 is a replication of one in the NATOPS Flight Manual. It does not depict the Ground Service Bus, which is depicted in the NATOPS Electrical System fold-out schematic.

1. Voltmeter reads 24 volts or less

2. Loss of generator bus equipment

3. Loss of nonessential services

C. Effects on flight safety

1. If generator will not reset, two good batteries will give power for 27 minutes. With only one good battery, power will only be available for 12 minutes

2. Requires maintaining VMC and landing as soon as possible

   NOTE: Reducing the electrical load on the batteries will prevent premature loss of emergency battery power.

V. Total electrical failure **1.8.1.3.1.4.1**

A. Indications

1. All electrically controlled flight instruments and controls cease to function

2. Loss of all lights (including emergency lighting)

3. Loss of the CWS

4. Various instrument flags appear

B. Verifications

1. Loss of flaps/slats, speed brakes, trim, and C AUG

2. Loss of all communication systems, navigation system, and all lighting

C. Effects on flight safety

1. Loss of primary flight instruments requires use of standby instruments (standby attitude indicator will be reliable for up to 9 minutes.)

2. Loss of communication and navigation systems isolates aircraft from air traffic control, external navigation aids, and other aircraft in vicinity

3. Loss of all trim

4. Loss of secondary flight controls

5. Requires emergency landing gear extension

6. Loss of boost pumps

7. Loss of cockpit lighting at night commands use of flashlights in cockpit

8. Pilot must maintain aircraft separation

9. Requires quick transition to VMC

10. Requires no-flap/slat landing

SUMMARY

This lesson has presented indications, verifications, and effects on flight safety of these electrical system malfunctions:

* AC inverter failure (single and double)
* Undervoltage condition
* Generator failure
* Total electrical failure

CONCLUSION

Being able to recognize electrical system malfunctions quickly is critical to your making safe and logical decisions in an emergency.

The conditions described in this lesson might occur in conjunction with each other. Your safety depends on your ability to evaluate a malfunction and make the correct decisions.

If this lesson has raised any questions for you, be sure to contact your instructor.

NOTES

FIGURES

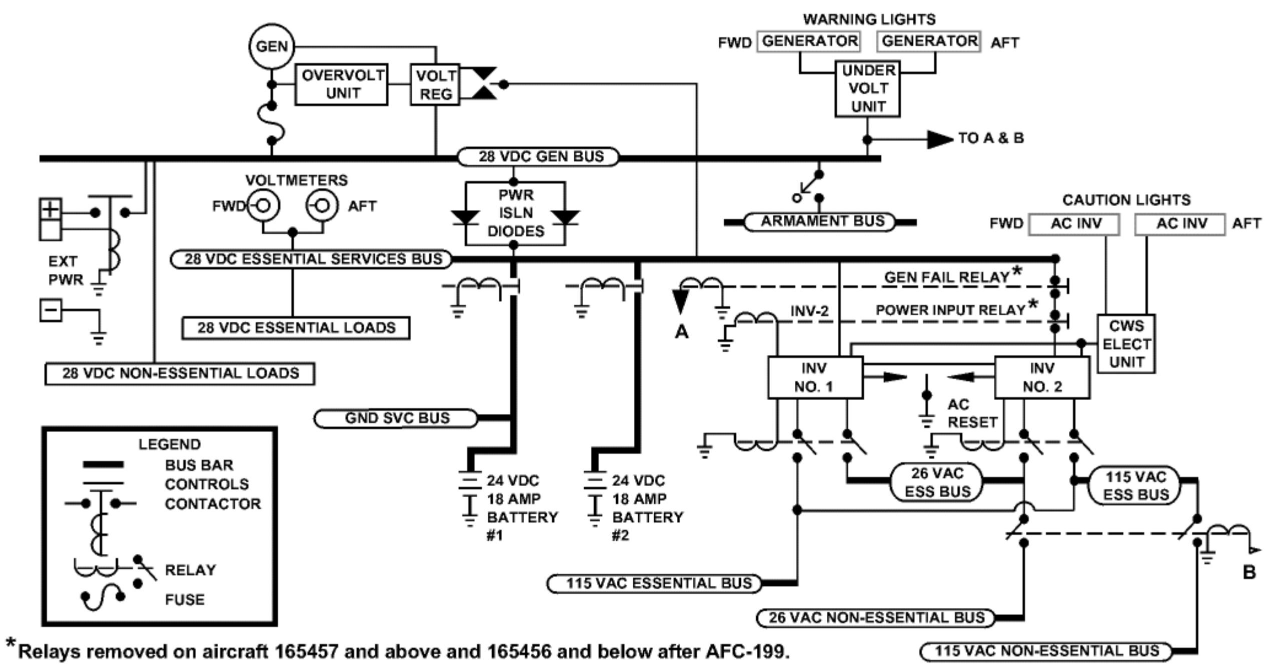


Figure 1: ELECTRICAL SYSTEM DIAGRAM

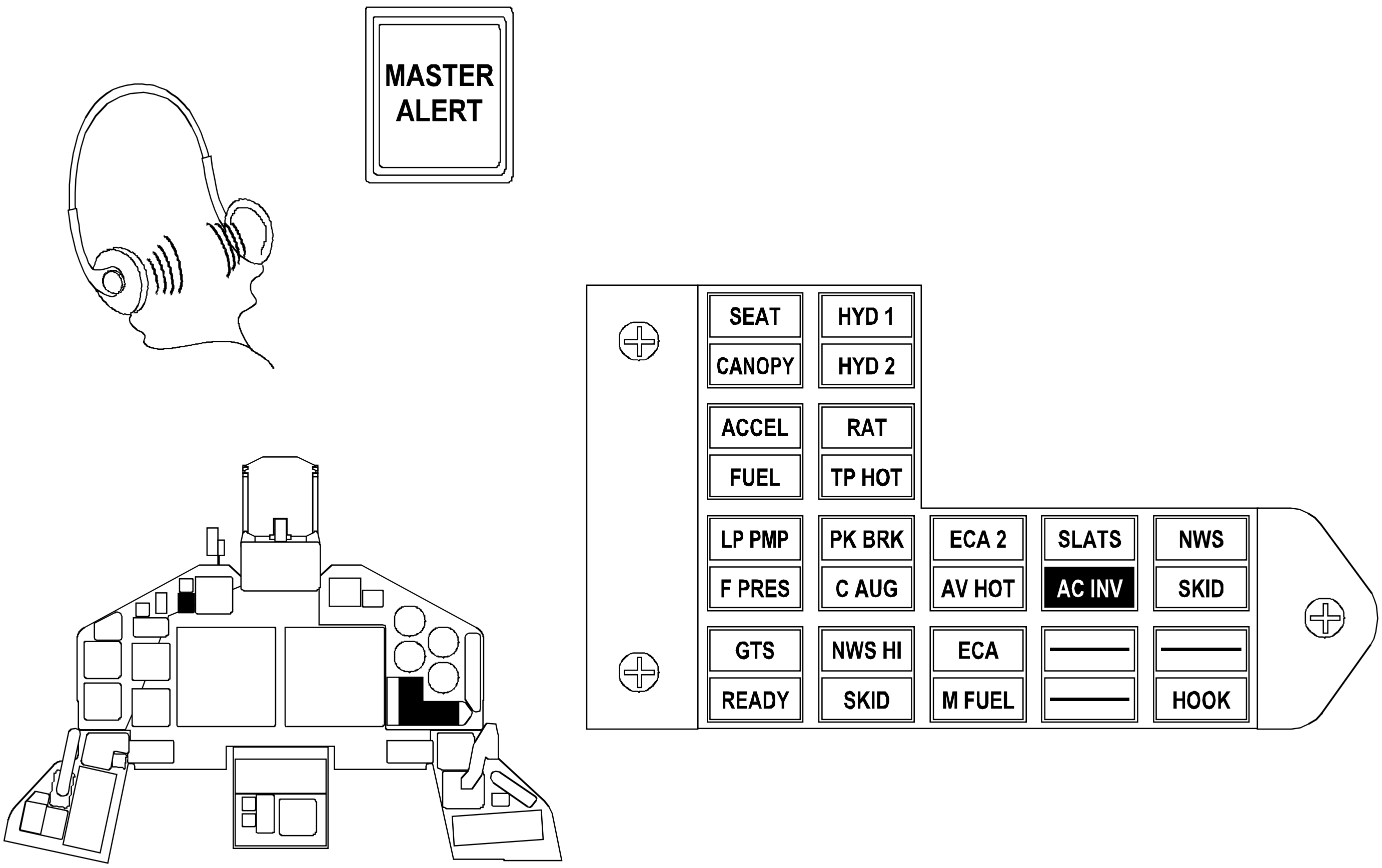


Figure 2: AC INVERTER FAILURE

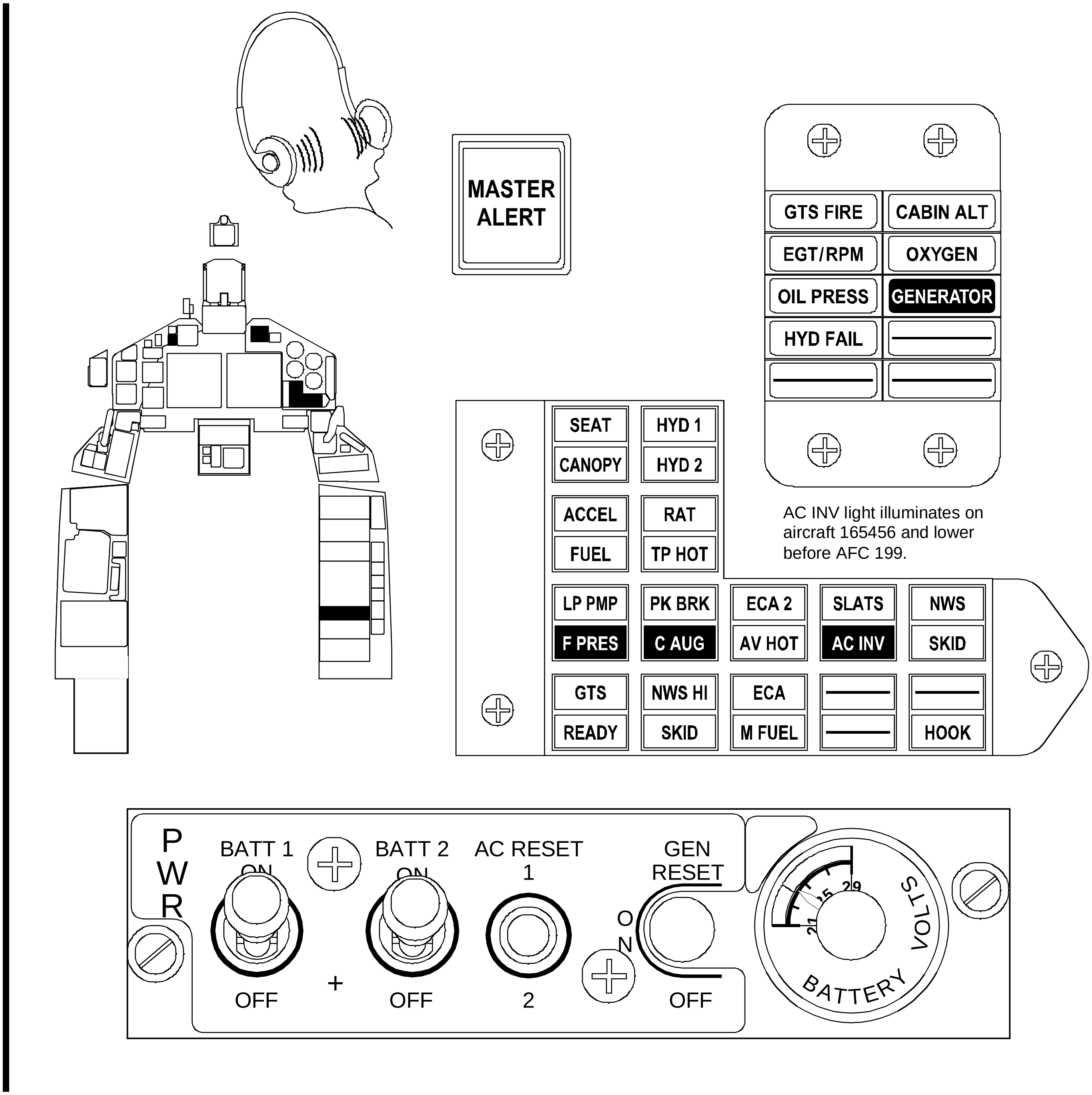


Figure 3: UNDERVOLTAGE CONDITION

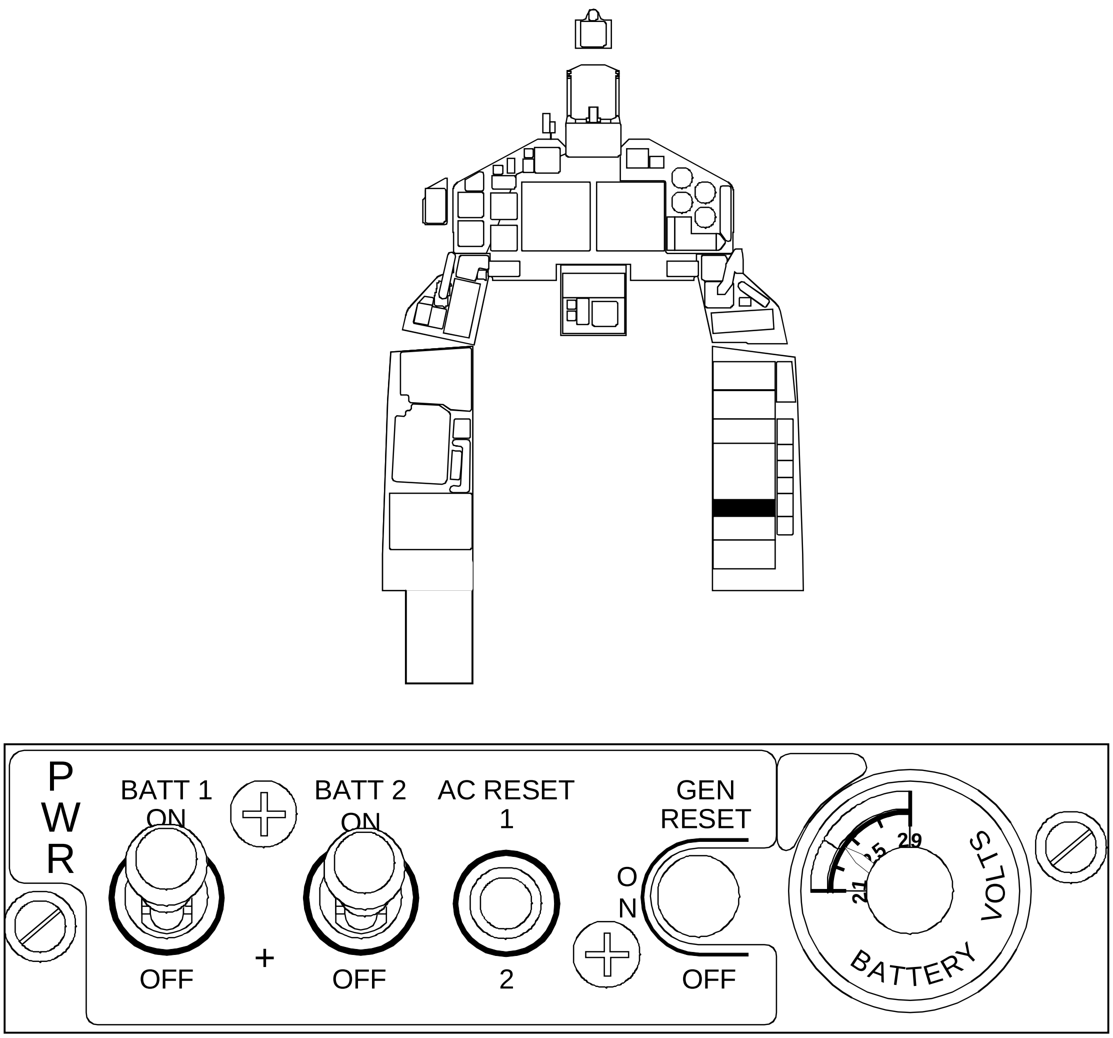


Figure 4: GENERATOR FAILURE WITH LOW BATTERY VOLTAGE

28VDC - GENERATOR BUS			
AC Isolation Relay ADRS Total Air Temp Htr Pwr Aileron Trim Control Aileron Trim Position Indicator Angle-of-Attack Heat Anti-collison Lights Baro Altimeter, Stby	Bombs Release Cabin Pressure Control 2 Comm Control Power B DEP, Fwd Flood Lighting GTS Drain Valve Landing/Taxi light Master Arm MDL Power	MFDs, Right (Both Cockpits) OBOGS Heat Overvoltage Unit Reticle Light Rockets Release Rudder Trim Control Stabilator Position Indicator	Stabilator Trim Standby UHF/VHF 2 Undervoltage Sensing Voltage Regulator VOR/ILS Control Yaw Damper

28VDC - ESSENTIAL SERVICES BUS			
Accel/Bleed Valve Control Accel/Bleed Valve Indicator ADI, Standby ADRS Angle-of-Attack Indicator Annunciator Lights Anti-Skid Control Approach Idle Stop Arresting Hook Cabin Pressure Control 1 Cabin Pressure Warning Cabin Temperature Control Caution Warning System Comm Control Pwr A DC Power External Supply DC Power Generator Reset DC Power Voltmeters-DEU [2]	Ejection Enable Switch (IFF) Emergency Jettison (Wing Station Only) Emergency Lighting Emergency NLG Door Actuation Control Engine Bleed Valve Engine Control & EGT Indicator Pwr Engine Vibration and Pressure Monitor External Power Fire Detection Flaps Control (Emer) Flaps Control Main Flaps Position Indicator Fuel Boost Pump Inverters [1] Fuel Boost Pumps Control [1] Fuel Flow Indicator Fuel System Control Fuel System Low Level Warning	Fuel System Quantity Indicator Generator Off-Load Generator Undervoltage GINA GTS Fuel/Oil Pump HYD 1, 2, & Brake Transducer Hydraulic 2 Bypass IFF Control IFF RCVR/XMTR Ignitors Inverters Protection Landing Gear Control Landing Gear Selector Valve Launch Bar Manual Fuel Sys Bleed Valve Time Delay Manual Fuel System Control Master Start 1 & 2 Master Switch Batt 2 MFD, Left (Both Cockpits) [2]	Navigation Light, Tail Nose Wheel Steering OBOGS Monitor OBOGS Shutoff Valve Pitot Probe Heat Press To Test Ram Air Turbine Reset Rudder Pedal Shaker Motor SADS [2] Seat Position Slats Position Indicator Speedbrake Control Speedbrake Position Indication Stabilator Trim Main TACAN Throttle Proximity Switches Turn/Slip Indicator UHF/VHF 1 VCR/CEU [2] Weight-on-Wheels Control

115 VAC BUSES		26 VAC BUSES	
ESSENTIAL	NON-ESSENTIAL	ESSENTIAL	NON-ESSENTIAL
Annunciator Lights (Night) Emergency NLG Door Act (Pwr) GINA (Synchro. Signal)	DEU Cooling Fan Radar Altimeter	TACAN ADR	DEU VOR/ILS/MB Yaw Damper

6 VAC BUSES		5 VAC NON-ESSENTIAL BUS
ESSENTIAL	NON-ESSENTIAL	
NAV Lights, Wing	Formation Lights	MIP Cockpit Lights
28 VAC NON-ESSENTIAL BUS		
Console Lights		

LEGEND

[1] Operate for 30 seconds after loss of generator bus.
[2] Operate for 2 minutes after loss of generator bus.

Figure 5: ELECTRICAL LOAD DISTRIBUTION

LECTURE GUIDE

COURSE/STAGE: TS, ADV & IUT / Engineering

LESSON TITLE: Engine and Related Systems

LESSON IDENTIFIER: T-45C TS, ADV & IUT ENG-04

LEARNING ENVIRONMENT: Classroom

ALLOTTED LESSON TIME: 1.5 hr

TRAINING AIDS:

* Wall Charts
  T-45C Cockpit
* Figures
  Fig 1: Engine Fuel System Block Diagram
  Fig 2: Engine Starting System Block Diagram
  Fig 3: Engine Lubrication System
  Fig 4: External Bleed Air
  Fig 5: Engine Controls
  Fig 6: Engine Oil Fill Gauge
  Fig 7: Simplified Fuel System Block Diagram

(9-98) CHANGE 5

STUDY RESOURCES:

* T-45C NATOPS Flight Manual, A1-T45AC-NFM-000

LESSON PREPARATION:

Read:

* Part I, Chapter 2.1, "Engine," T-45C NATOPS Flight Manual, A1-T45AC-NFM-000
* Part I, Chapter 4, "Operating Limitations," T-45C NATOPS Flight Manual, A1-T45AC-NFM-000

REINFORCEMENT: N/A

EXAMINATION:

Student is required to read engine system and related malfunctions paragraphs in the NATOPS Flight Manual, receive classroom instruction, and complete assigned CAI lesson(s). The student shall demonstrate knowledge by completing, from memory with 80% accuracy, true/false and multiple choice block examinations. The objectives in this lesson will be tested in either Engineering 29X or Engineering 30X.

LESSON OBJECTIVES

1.4.6.3.1
Recall major components of the engine system

1.4.6.2.1
Recall operating characteristics of the engine system

1.4.6.5
Recall engine operating limitations

1.4.6.3
Recall function, purpose, and location of engine system controls, switches, and indicators

1.4.6.4
Recall procedures for servicing the engine system

1.4.6.2
Recall interface between the engine system and other a/c systems

MOTIVATION

You must learn the basics of turbofan engine operating characteristics as well as the specific procedures and limitations for the Adour Engine to safely fly your aircraft to the edges of the envelope.

OVERVIEW

In this lesson we will be covering the:

* Major components of the T-45C engine
* Engine operating characteristics
* Purpose, function, and location of T-45C engine system controls, switches, and indicators
* Engine servicing
* Interfaces between the engine and other T-45C systems

REFRESHER

Recall basic turbine engine operating principles and related subsystems that are powered by the engine accessory section.

PRESENTATION

I. Engine system major component identification **1.4.6.3.1**

LESSON NOTES

Direct your students to use the basic engine diagram (Figure 1) and the basic engine block diagram (Figure 2) for reference throughout this lesson.

A. Engine: twin spool, medium bypass, axial flow turbofan producing approximately 5527 lb of thrust

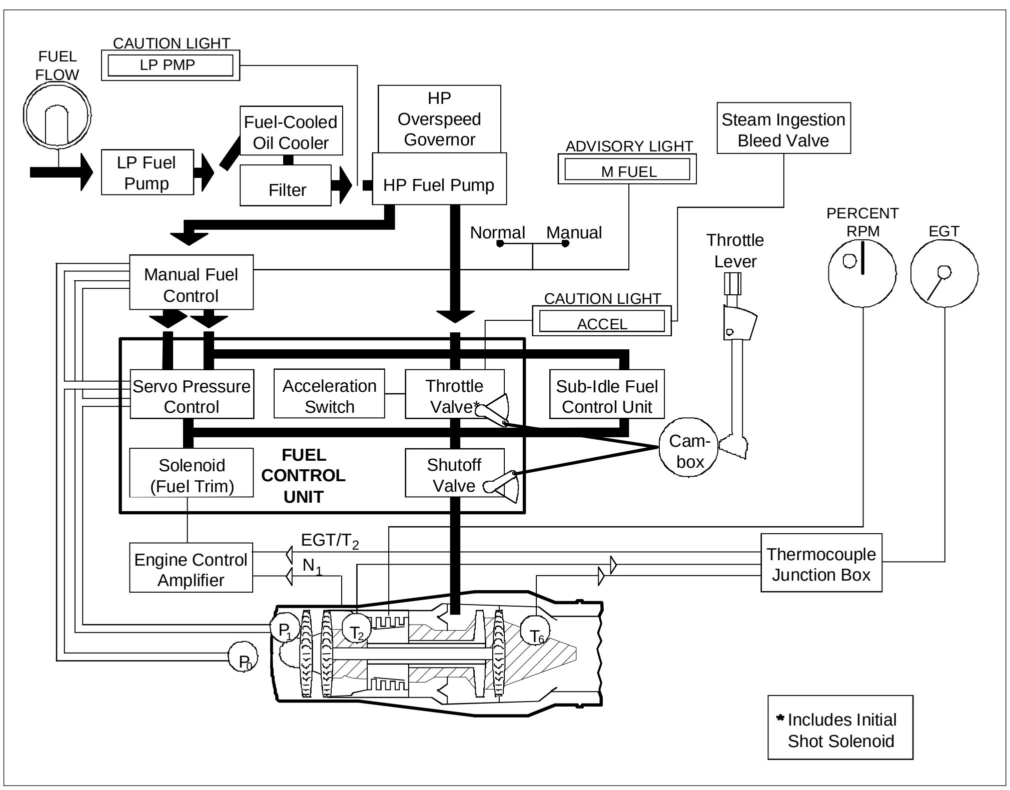


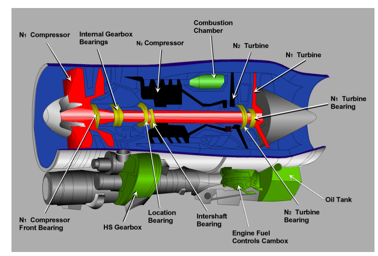
Figure 1: ENGINE FUEL SYSTEM BLOCK DIAGRAM

Sg 1, fr 2
Lesson Organization

ENGINE AND RELATED SYSTEMS

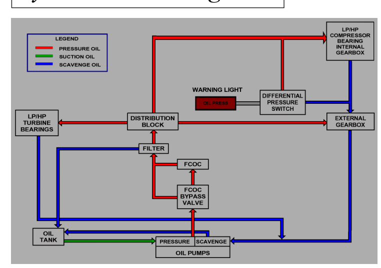
- **Major components of the T-45C engine**
- Engine operating characteristics
- Controls, switches, and indicators
- Engine servicing
- Engine/aircraft interfaces

Sg 1, fr 3
Basic Engine Diagram



Sg 1, fr 4
Fig 1: Engine Fuel System Block Diagram

Sg 1, fr 5
Engine Lubrication System Block Diagram



Sg 1, fr 6
Fig 2: *Engine Starting System Block Diagram*

B. Engine fuel system: engine-driven low- and high-pressure fuel pumps with manual and automatic fuel metering controls

C. Engine lubrication system: self-contained, engine-driven, full-flow recirculating system

D. Engine starting system

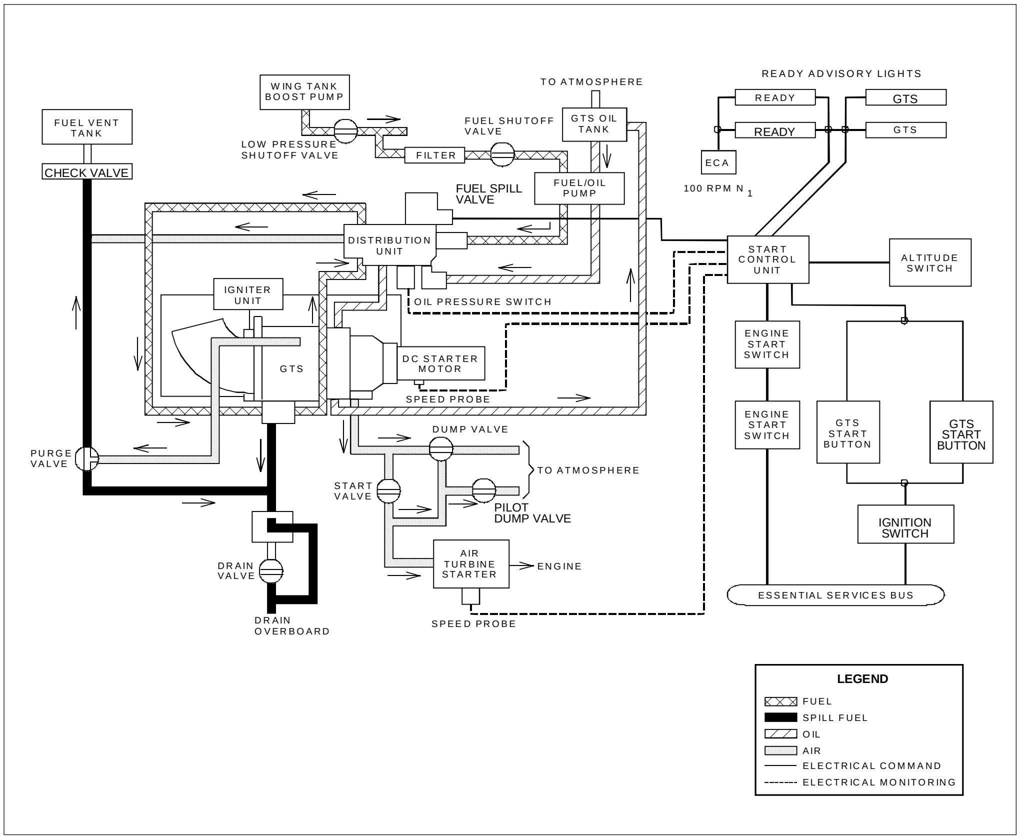


Figure 2: ENGINE STARTING SYSTEM BLOCK DIAGRAM

1. Gas turbine starter (GTS)

    a. Location: airframe-mounted on central fuselage above engine

    b. Description: self-contained, two-stage air-starting system, powers the air turbine starter which provides engine rotation

2. Air turbine starter (ATS)

    a. Location: mounted to external engine gearbox

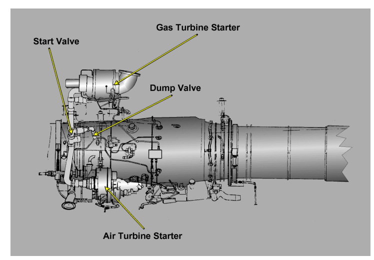
    b. Description: consists of a turbine driven by air from the GTS. Air turbine starter drives engine N_2 shaft through the accessory gearbox and provides assistance until approximately 45% rpm has been achieved

3. Sub-idle fuel control unit (SIFCU)

    a. Location: mounted to engine gearbox assembly

    b. Description: meters fuel to spray nozzles during start cycle to ensure proper initial acceleration

Sg 1, fr 7
Engine Start System

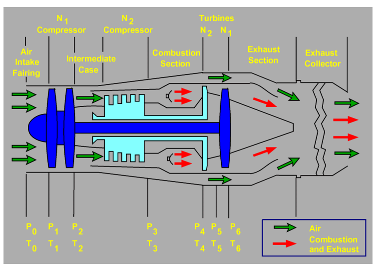


Sg 2, fr 2
Lesson Organization

ENGINE AND RELATED SYSTEMS

* Major components of the T-45C engine
* **Engine operating characteristics**
* Controls, switches, and indicators
* Engine servicing
* Engine/aircraft interfaces

Sg 2, fr 3
Engine Pressure and Temperature



II. Engine operating characteristics **1.4.6.2.1**

LESSON NOTES

Use the graphic displayed in Sg 2, fr 3 (Fig 6: Engine Pressure and Temperature) throughout the discussion on engine operating characteristics.

A. Engine

1. Air intake and compression

   a. Compressor (N_1): two compressor stages with a 2.5:1 pressure ratio

   (1) Compresses intake air for N_2 compressor (acts as turbocharger)

   (2) Output split between N_2 compressor and annular bypass duct, with 40% bypassed to exhaust nozzle

   b. Compressor (N_2): five compressor stages with a 4.4:1 pressure ratio, which raises air pressure and discharges it into combustion chamber

   NOTE: Overall compression ratio is approximately 11:1.

   c. Bypass air (N_1 compressor air)

   (1) N_1 compressor bypass air is routed through an annular bypass duct and mixed with turbine exhaust gases in exhaust mixer

   (2) Small portion of bypass air is tapped from bypass duct and used to cool exhaust cone

2. Combustion (N_2 compressor air)

   a. Fuel from fuel control system introduced through 18 fuel spray nozzles and mixed with N_2 compressed air in annular combustion chamber

   b. Fuel/N_2 air mixture ignites and expands, forcing high pressure gases into turbine section

3. Power generation

   a. N_2 and N_1 turbines extract energy from gases exiting combustion chamber to drive their respective compressors through coaxial shafts

   b. Internal gearbox extracts mechanical energy from N_2 shaft, providing power to external gearbox

   c. External gearbox mechanically drives engine and aircraft accessories, e.g., generator, hydraulic pumps, and fuel pumps

4. Exhaust: annular bypass air mixes with turbine gases in exhaust mixer and exits through fixed convergent nozzle and tailpipe

5. Monitoring **1.4.6.5**

   a. RPM: sensed by a tachometer generator attached to high-speed gearbox measures N_2 shaft speed

      (1) Max rpm: 104%

      (2) Max continuous rpm: 100%

      (3) Idling speed: 55 +/- 2% at sea level (with bleed valve closed)

   b. Exhaust gas temperature (EGT): thermocouple

Sg 2, fr 4
Engine Instruments & MFD Engine Display

b. Exhaust gas temperature (EGT): thermocouple junction box derives EGT information from two thermocouples mounted in gas flow just aft of N_1 turbine

(1) T2 thermocouple, mounted in airstream just aft of N_1 compressor, measures input (ambient) air temperature

(2) Military Rated Thrust (MRT): 610 degrees C, time restricted to 30 minutes per flight hour

(3) Maximum continuous: 550 degrees C, time unrestricted

(4) Idle: 450 degrees C, time unrestricted

(5) Transient/acceleration: 645 degrees C, time restricted to less than 20 seconds

(6) Ground start: 550 degrees C

(7) Transient during ground start: 20 degrees C overshoot, time restricted to 10 seconds

(8) Airstart: 600 degrees C

(9) Transient during airstart: 50 degrees C overshoot, time restricted to 10 seconds

c. Fuel flow

(1) Idle: 300-400 pph

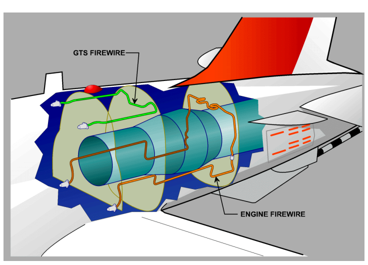
(2) Maximum: 6410 pph

d. Fire detection system

(1) Consists of two sets of automatic resetting firewire elements

(a) One encircles engine bay

Sg 2, fr 4
GTS and Engine Firewire Location



(a) One encircles engine bay

(b) One encircles GTS bay

(2) Detects fire or overheat condition in GTS and engine bays

(3) Fire detected if engine or GTS bay temperature reaches 300 degrees C (572 degrees F)

(4) Warning light will go out if the temperature falls below 300 degrees C for up to 45 sec

e. Tailpipe hot detection system

(1) Consists of four thermo detector type sensors

(2) TP HOT Caution Light on if tailpipe bay temperature exceeds 150 degrees C (302 degrees F)

B. Engine fuel system

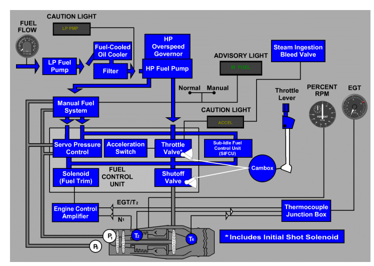
1. Normal fuel control

a. Functional description: fuel transferred to engine LP fuel pump from aircraft fuel system. Automatic (NORMAL) controls override mechanical controls, preventing engine from exceeding operating limits (when FUEL CONTROL switch set to NORMAL)

(1) LP fuel pump: mounted on and driven by external gearbox, pump maintains fuel pressure to HP fuel pump, preventing HP fuel pump cavitation

(2) Fuel-cooled oil cooler (FCOC): mounted on engine accessory package, heat exchanger unit transfers oil heat to fuel, reducing or eliminating fuel system icing

Sg 2, fr 5
(10 Overlays)
Engine Fuel System
Block Diagram



Overlay 1
LP Fuel Pump

Overlay 2
FCOC

Overlay 3
Filter

Overlay 4
HP Fuel Pump

(3) Filter: removes foreign matter from fuel

(4) HP fuel pump: mounted on and driven by external gearbox, supplies HP fuel to fuel control unit (FCU) and SIFCU

(a) Maintains constant fuel pressure throughout engine speed fluctuations

Overlay 5
FCU

(5) FCU: fuel flow scheduling unit with acceleration control and altitude and airspeed compensation

LESSON NOTES

Explain characteristics of engine surge margin. Explain how the initial shot solenoid affects engine surge margin.

(a) Initial shot solenoid provides increased fuel flow to increase engine surge margin during engine acceleration

i) Enabled when altitude decreases through 7,700 +/- 500 feet

ii) Disabled when altitude increases through 9,500 +/- 300 feet

Overlay 6
Acceleration Switch

(b) Acceleration switch dampens throttle valve response for rapid throttle movements

Overlay 7
Servo Pressure Control

(c) Servo pressure control maintains constant pressure drop across throttle valve, compensating for changes in airspeed and altitude

(d) Solenoid (fuel trim): trims basic fuel flow in response to engine control amplifier (ECA) inputs

Overlay 8
Solenoid (Fuel Trim)

(e) ACCEL caution light illuminates if solenoid not in commanded position

(6) ECA: located in lower equipment bay, trims fuel flow to maintain EGT and N_1 rpm within limits

Overlay 9
ECA

(a) Two independent control modules (lanes) which adjust fuel trim in conjunction with fuel trim solenoid

i) Each lane operates independently, with only one in control

ii) If one lane fails, green ECA advisory illuminates, and backup lane takes control (no engine protection is lost, engine functions normally)

iii) If both lanes fail, ECA 2 caution light illuminates

NOTE: If an ECA lane failure occurs, a momentary thrust fluctuation may be experienced. With a dual lane failure, engine EGT, fuel flow, and rpm should be monitored and the throttle carefully controlled. Manual fuel control use should be considered only if a dual lane failure is indicated and engine instability exists; for instance, stalls or surges.

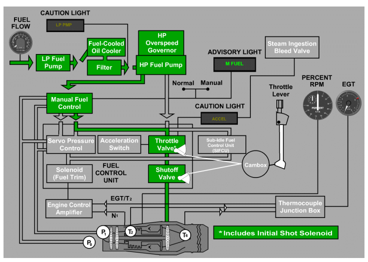
(b) If either EGT or N_1 shaft speed exceeds operating limits, ECA signals the FCU, reducing fuel flow

Overlay 10
SIFCU

(7) SIFCU: meters fuel to spray nozzles during start cycle to ensure proper initial acceleration

b. Monitoring: fuel flow is automatically controlled by FCU in conjunction with ECA and throttle position when FUEL CONTROL switch set to NORMAL

Sg 2, fr 16
Manual Fuel System



2. Manual fuel control system

a. Functional description

(1) Operates similarly to main fuel control, but automatic engine limiting controls do not function (FUEL CONTROL switch set to MANUAL)

NOTE: In manual fuel control, special precautions must be observed because automatic fuel control protections are inoperative.

(2) Receives fuel from HP fuel pump

NOTE: Complete loss of electrical power precludes switching the fuel control from the position selected.

(3) Throttle directly controls engine fuel metering

(4) Special cautions must be observed because automatic fuel protections are inoperative

(a) Rapid throttle movements may cause erratic engine operation

CAUTION: Selecting manual fuel at high rpm may result in exceeding rpm or EGT limits.

(b) SIFCU inoperative when MANUAL FUEL is selected

CAUTION: Starting the engine on the ground with manual fuel control is not permitted.

(c) Acceleration switch inoperative: acceleration may take longer

(d) ECA inoperative: pilot must monitor and control N_2 shaft rpm and EGT through throttle movements

b. Monitoring: engine indications (RPM, EGT, and FUEL FLOW) in manual fuel control same as normal fuel control indications

C. Engine lubrication system

Sg 2, fr 17
Fig 3: *Engine Lubrication System*

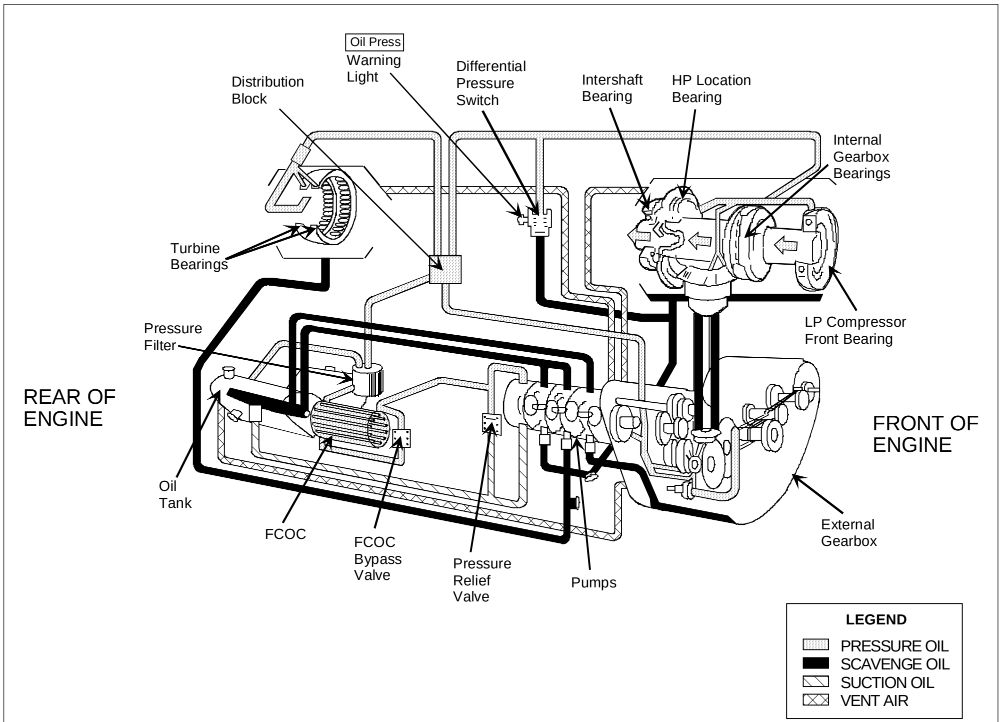
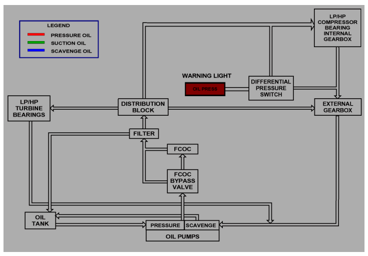


Figure 3: ENGINE LUBRICATION SYSTEM

Sg 2, fr 18
(9 Overlays)
Engine Lubrication System Block Diagram



Overlay 1
Oil Tank

Overlay 2
Oil pump

Overlay 3
FCOC

Overlay 4
FCOC Bypass Valve

Overlay 5
Filter

Overlay 6
Distribution Block

Overlay 7
Differential Switch

1. Functional description

   a. General

      (1) Provides lubrication of engine shaft bearings and internal and external gearboxes

      (2) Oil pump: draws oil from oil tank and maintains pressure to engine and gearbox oil systems

   b. Components

      (1) Oil tank and system: contains approximately 25.2 U.S. pints with unusable, quantity of 9.6 U.S. pints

      (2) Oil pumps: engine-driven, mounted on the accessory gear box

      (3) FCOC

         (a) Heat exchanger unit provides oil cooling through heat exchange with engine fuel

         (b) Integrated FCOC bypass valve ensures adequate engine lubrication under cold temperature conditions

      (4) Oil filter: filters all oil entering engine and gearboxes

      (5) Distribution: oil distributed to engine turbine bearings, engine internal gearbox, and external gearbox

      (6) Oil differential switch

         (a) Measures pressure differential between internal gearbox oil feed and scavenge

(b) Signals centralized warning system (CWS) if the differential oil pressure drops below 10 psi, causing OIL PRESS warning light to illuminate

Overlay 8
OIL PRESS Warning Light

(c) Incorporates a 10 second delay to avoid signaling transient pressures

(7) Scavenge system

(a) Three oil pumps scavenge and return oil to oil tank from three distribution areas

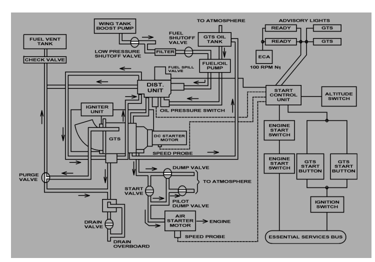
Overlay 9
Scavenge System

(b) Scavenge return lines contain magnetic chip detectors and return oil strainers to safeguard engine components

2. Monitoring

a. Oil differential switch measures pressure differential between internal gearbox oil-feed and scavenge and signals CWS if oil pressure drops below 10 psi. There is no oil pressure gauge in cockpit.

Sg 2, fr 28
(10 Overlays)
Engine Starting System Block Diagram



b. Oil tank sight gauge monitored by ground crew (aircrew for cross-country flights)

c. Minimum oil level for flight: 2 liters (4.2 U.S. pints) below FULL mark. Consumption is approximately 0.8 pints per flight hour

D. Engine starting system: engine is started (on ground or by assisted relight in flight) via GTS and ATS

1. Starting system component function

Overlay 1
GTS

Overlay 2
Input Power

Overlay 3
Fuel

a. GTS: gas turbine air producer unit

(1) GTS starter motor and GTS igniters powered by 28 VDC essential services bus

(2) GTS fuel obtained from aircraft fuel system downstream from LP fuel shutoff valve

Overlay 4
GTS Start Button

Overlay 5
GTS Advisory Lights

(3) Started by pressing GTS start button

(a) When GTS reaches speed, a green GTS advisory light illuminates in both cockpits and GTS starter motor disengages

Overlay 6
Dump Valve

(b) Dump valve routes excess GTS air overboard

Overlay 7
Engine Start Switch

(c) GTS accelerates to 100% for engine starting when ENGINE start switch is momentarily set to START

Overlay 8
Start Valve

(4) When engine start switch is momentarily set to START, the GTS accelerates, the start valve is opened, the dump valve closes and the GTS supplies compressed air to the engine ATS

(5) Shuts down after engine reaches 45% rpm

Overlay 9
Air Starter

b. ATS: air turbine starter output shaft drives engine N_2 shaft through external gearbox

NOTE: The starting system does not feed air into the engine.

(1) Sprag clutch allows engine to overrun ATS upon engine start

c. Start control unit

Overlay 10
Starter Control Unit

(1) Sequences start cycle by monitoring speeds of GTS, air turbine starter, and engine

(2) Electrically off-loads DC generator and HYD 2 system until engine N_2 rpm reaches 45% to ease strain on ATS

(3) Shuts down GTS and engine ignition when engine N_2 rpm reaches 45%

2. Engine starting component function

a. Bleed air valve: relieves pressure from N_2 compressor to ease engine starting and prevent compressor stalls

(1) Engine off and initial acceleration

(a) Electrically actuated, spring-operated valve opens when low differential fuel pressure signal is received during engine start (initially with engine off, valve is open)

(b) Valve held open by spring and differential air pressure (between N_2 and bypass duct) during start and initial engine acceleration

(c) Valve closed pneumatically by P3 air when N_2 rpm reaches 61 +/- 4%

NOTE: When the valve closes, rpm increases approximately 3% and EGT decreases approximately 50 degrees C.

(2) Engine running: valve held closed pneumatically by P3 air after engine start and all other throttle movements

(3) Engine shutdown: spring opens valve when engine speed reaches approximately 45% rpm during rundown

(4) Starting with manual fuel selected (FUEL CONTROL switch set to MANUAL): bleed air valve opened electrically by pressing GTS start button—valve held open for 60 seconds

Sg 2, fr 39
***Fig 4:** External Bleed Air*

CAUTION: Starting the engine on the ground with manual fuel control is not permitted.

b. Igniters: two high-energy 12 joule igniter plugs fitted to engine combustion chamber

(1) Powered by 28 VDC essential services bus, produce approximately 80 sparks per minute

(2) Controlled by IGNITION switch and starter control unit during normal start

(3) Controlled by GTS start button during air start—igniters energized while GTS start button is pressed (+30 seconds when airborne)

3. Monitoring: includes monitoring of all normal engine parameters plus three parameters specific to engine start—GTS fire, GTS rpm, and direction of engine rotation

E. Bleed air system

1. Internal air flow: continuous flow of compressor air, used internally in engine for

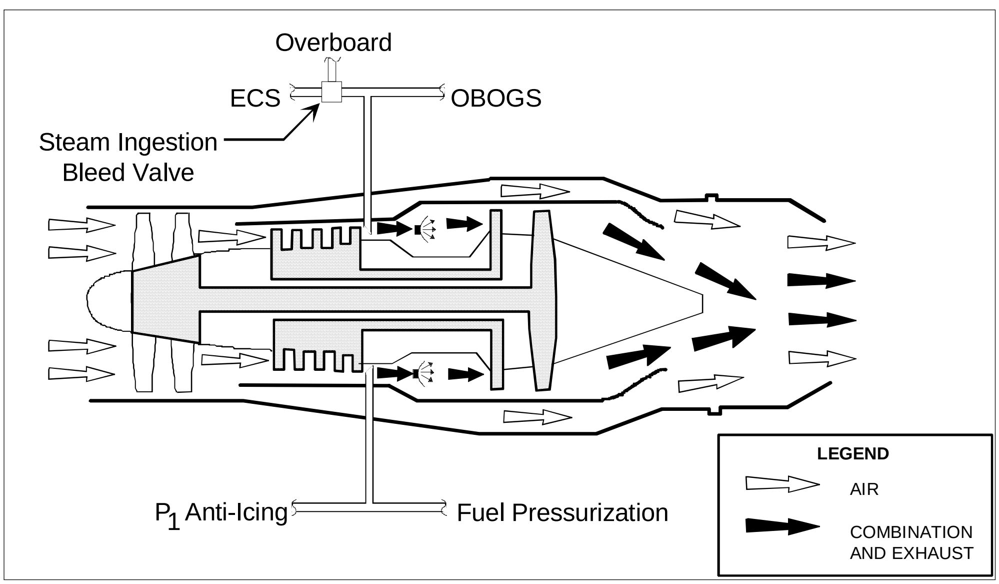


Figure 4: EXTERNAL BLEED AIR

a. Pressurizing oil seals to prevent oil bleeding into engine air flow and hot gases from entering oil system

b. Cooling

(1) Engine shafts and bearing thrust loading

(2) Rear face of N_2 turbine

(3) Both sides of N_1 turbine

(4) N_1 turbine vane

(5) N_2 turbine bearings

c. Anti-icing intake spinner

2. External air flow: fifth-stage N_2 compressor delivery air (P3), tapped from four areas on engine case for

a. On-board oxygen generating system (OBOGS)

b. Environmental control system (ECS) and overboard engine bleed

c. Fuel tank pressurization

d. P1 probe anti-icing

F. Bleed air vents: two bleed valves that have significant effects on engine operation, one functions during engine start, and the other functions during catapult launch

1. The engine bleed valve relieves pressure from N_2 compressor during engine start and prevents N_1 compressor stalls (approx. 25% loss of thrust)

2. A steam ingestion bleed valve vents additional bleed air from the N_2 during (approx. 10% loss of thrust)

a. Catapult launch to preclude compressor surge due to steam ingestion

a. Catapult launch to preclude compressor surge due to steam ingestion

(1) Valve commanded open when

(a) LAUNCH BAR is EXTENDED

(b) Weight on wheels

(c) N_2 above 70%

(2) Valve held open until

(a) Weight off wheels or

(b) N_2 below 70% rpm

(3) ACCEL caution light illuminated when valve position disagrees with commanded position, OPEN or CLOSED

PROGRESS CHECK

Question 1 — 1.4.6.2.1
What are the minimum and maximum normal fuel flow indications?

ANSWER:
1. Minimum: 300 pph
2. Maximum: 6410 pph

III. Engine system controls, switches, and indicators **1.4.6.3**

A. Cockpit controls: all engine function controls located on left consoles, both cockpits

1. IGNITION switch (fwd cockpit only)

a. NORMAL (guarded): controls power supply to ignition system

b. ISOLATE: deenergizes ignition system

2. ENGINE start switch

a. START (spring loaded to ON): accelerates GTS to full power to start engine, closes GTS dump valve, routes air to ATS

b. ON: energizes start control unit

c. OFF: manually shuts down GTS operation and deenergizes start control unit

3. GTS start button

a. When momentarily pressed, starts the GTS and energizes ignition

b. Activates engine igniters for duration of press both on the deck and airborne

NOTE: GTS button will activate igniters for duration of press + 30 seconds when airborne. On deck will activate for duration of press; 30 second period begins when ECA passes READY signal.

4. Throttle friction knob (fwd cockpit only): when rotated, adjusts throttle friction. Clockwise rotation increases friction.

Sg 3, fr 2
Lesson Organization

ENGINE AND RELATED SYSTEMS

* Major components of the T-45C engine
* Engine operating characteristics
* **Controls, switches, and indicators**
* Engine servicing
* Engine/aircraft interfaces

Sg 3, fr 3
(5 Overlays)
Fig 5: *Engine Controls*

Overlay 1
Engine Start Switch

Overlay 2
GTS Start Button

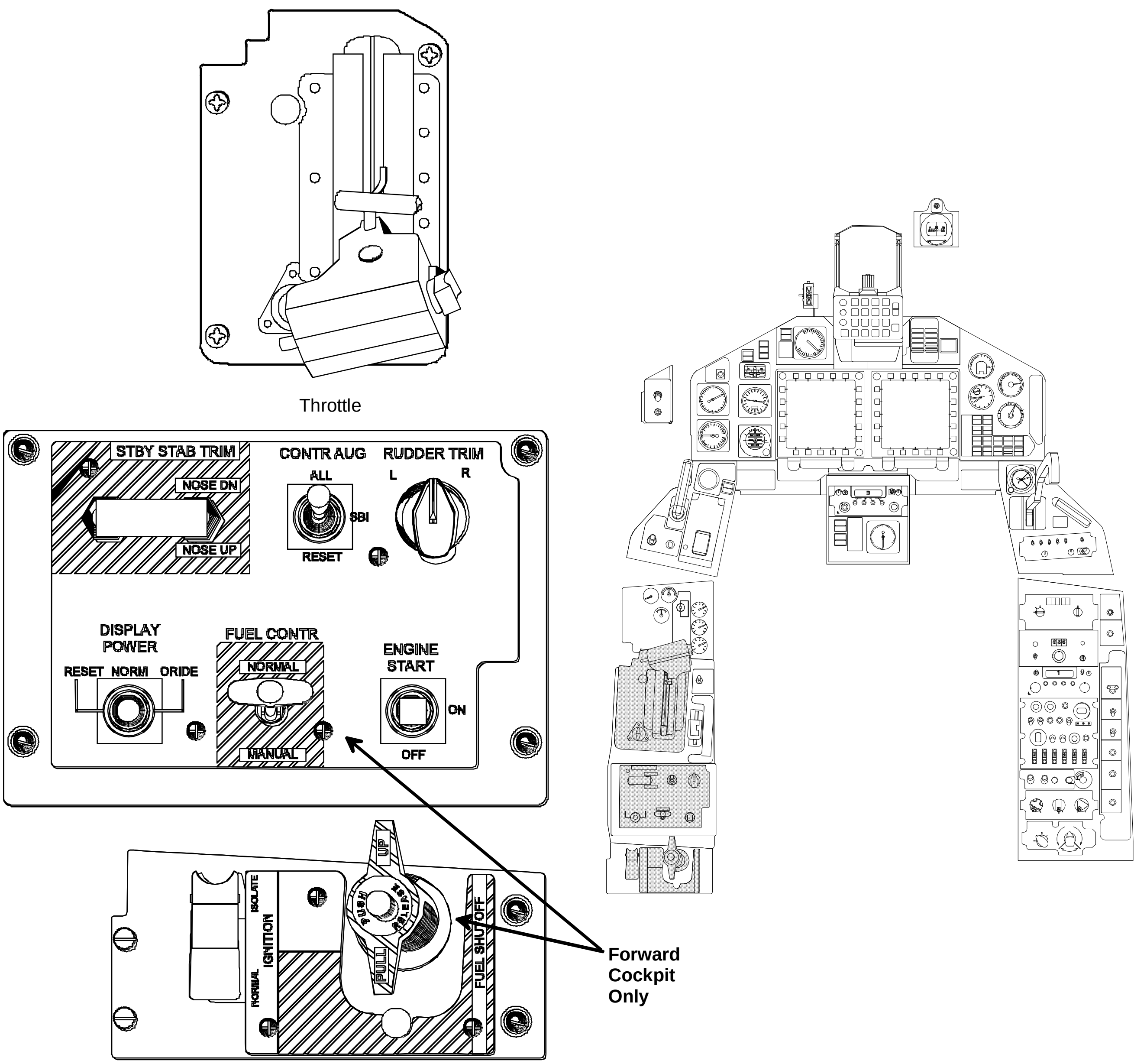


Figure 5: ENGINE CONTROLS

5. Throttle

Overlay 3
Throttle

   a. OFF: interrupts or prevents fuel flow to engine

   b. IDLE: opens fuel shutoff valve to direct fuel to fuel spray nozzles

   c. APPROACH IDLE: with landing gear down and aircraft weight off wheels, maintains minimum rpm at approximately 72%

      (1) Field landing: with anti-skid ON, the approach idle stop is withdrawn immediately upon MLG weight on wheels

      (2) Carrier landing: with anti-skid OFF, the approach idle stop is withdrawn two seconds after touchdown

   d. Full forward: operates engine at military rated thrust (MRT)

6. Idle stop lever: when pulled, permits movement of throttle past APPROACH IDLE stop to OFF

   a. Located on front of throttle below throttle grip in both cockpits

   b. Pulling lever up allows throttle to be moved aft past approach idle stop (if engaged) or idle stop (throttle off)

      NOTE: The stop lever should be gradually released while moving the throttle from APPROACH IDLE to IDLE. The lever should be pulled again to move the throttle past APPROACH IDLE stop and IDLE stop to OFF.

7. FUEL CONTROL switch (lever-locked)

Overlay 4
Fuel Control Switch

   a. NORMAL: selects main fuel control system

   b. MANUAL: selects manual fuel control system

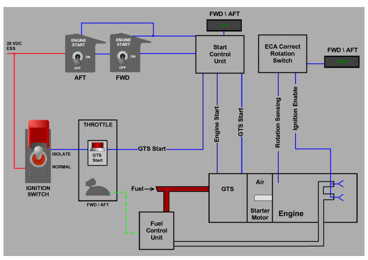
Overlay 5
Fuel Shutoff Handle

8. FUEL SHUTOFF handle (fwd cockpit only)

   a. Down: permits fuel flow to supply engine and GTS

   b. Pull up: isolates aircraft fuel system from the engine and GTS

Sg 3, fr 9
(6 overlays)
Engine Start Switchology--Simplified



Overlay 1
Ignition Switch

Overlay 2
Engine Start Switch

Overlay 3
GTS Start Button

Overlay 4
Engine Start Switch

LESSON NOTES

Use the following as a key when explaining the engine start process using the simplified engine start switchology graphic.

1. *IGNITION switch - NORMAL*

2. *ENGINE START switch - ON*

3. *GTS start button - PRESS (Momentarily)*

   a. *GTS starts*

      NOTE: Engine ignition is activated when GTS button is pressed. (Will remain energized for 30 seconds after its release if airborne)

   b. *GTS advisory light on within 20 sec*

4. *ENGINE START switch - START (momentary)*

   a. *GTS accelerates to full power, start valve opens, and dump valve closes*

   b. *READY advisory light on when engine N_1 rpm reaches 100 rpm in the correct direction, engine ignition activates*

LESSON NOTES (cont.)

5. Throttle - IDLE WHEN RPM REACHES 15% N_2 MINIMUM

a. Sub-idle fuel control unit (SIFCU) schedules fuel to combustion chamber and lightoff must occur within 15 sec

NOTE: The C AUG caution light, MASTER ALERT light and CAUTION TONE will illuminate/sound during ground starts when the RPM is between 30% and 36%

b. Engine should accelerate to 45% within 28 sec

(1) At 45% N_2:

(a) GTS shuts down

(b) Generator comes on line

(c) READY advisory light goes out

(d) Ignition is deenergized

6. Engine accelerates to IDLE (approx. 52%) within 30 sec after

7. Advance throttle slowly to 70% N_2. (SOP)

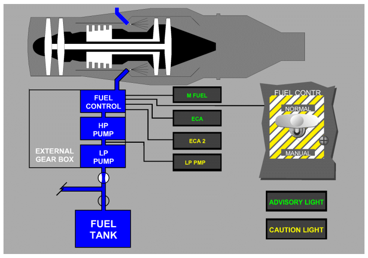
NOTE: Bleed valve closure should occur at 61 +/- 4%.

8. Return throttle to idle stop and check N_2 stabilizes at (approx. 55 +/-2%)

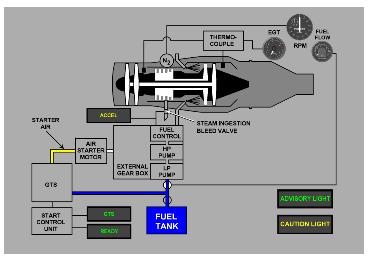
Overlay 5
Throttle - Idle

Overlay 6
45% N_2 rpm

Sg 3, fr 16
Engine Indicators,
1 - 4



Sg 3, fr 17
Engine Indicators,
5 - 10



B. Cockpit indicators

1. M FUEL advisory light: indicates manual fuel control system selected

2. ECA advisory light: indicates single-lane ECA failure

3. ECA 2 caution light: indicates total engine control amplifier failure (both lanes)

4. LP PMP caution light: indicates engine-driven low pressure fuel pump failure or clogged low pressure fuel filter (<35 psi)

5. ACCEL caution light: indicates initial shot solenoid valve and/or steam ingestion bleed valve is not in the commanded position

LESSON NOTES

Emphasize the different engine performance limitations the pilot should anticipate with an illuminated ACCEL caution light.

6. READY advisory light: indicates a low pressure (N_1) shaft speed of 100 rpm or greater in the correct direction of rotation and the igniters are energized

7. GTS advisory light: indicates gas turbine starter has attained idling speed prior to engine start

8. RPM indicator: indicates N_2 compressor speed in percent rpm

9. EGT indicator: indicates exhaust gas temperature in degrees C

10. FUEL FLOW indicator: indicates rate of fuel flow to combustion chamber in pounds per hour (pph)

11. FIRE warning light: indicates engine bay temperature exceeds limits (572 degrees F/300 degrees C)

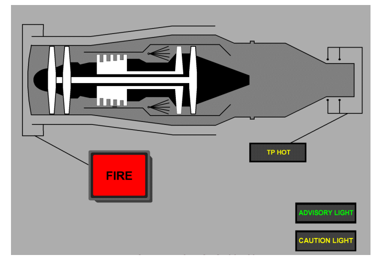
12. TP HOT caution light: indicates tailpipe bay temperature exceeds limits (302 degrees F/150 degrees C)

13. GTS FIRE warning light: indicates GTS bay temperature exceeds limits (572 degrees F/300 degrees C)

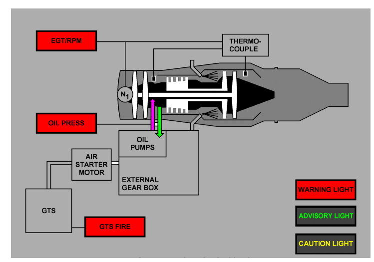
14. EGT/RPM warning light: indicates either EGT or N_1 RPM exceeds limits (650 +/- 8 degrees C/112.4% +/- 1% RPM)

15. OIL PRESS warning light: indicates low oil pressure differential (<10 psi)

Sg 3, fr 18
Engine Indicators, 11 - 12



Sg 3, fr 19
Engine Indicators, 13 - 15



PROGRESS CHECK

Question 2 — 1.4.6.3
What cockpit control removes power from the starter control unit?

ANSWER: The ENGINE start switch (both cockpits), marked ENGINE - OFF/ON/START (spring loaded from START to ON), removes power to the starter control unit when set to the OFF position.

Sg 4, fr 2
Lesson Organization

ENGINE AND RELATED SYSTEMS

* Major components of the T-45C engine
* Engine operating characteristics
* Controls, switches, and indicators
* **Engine servicing**
* Engine/aircraft interfaces

Sg 4, fr 3
Fig 6: *Engine Oil Fill Gauge*

IV. Servicing **1.4.6.4**

NOTE: Aircraft servicing is normally handled by the ground crew. However, during cross-country flights, the pilot must ensure proper aircraft servicing.

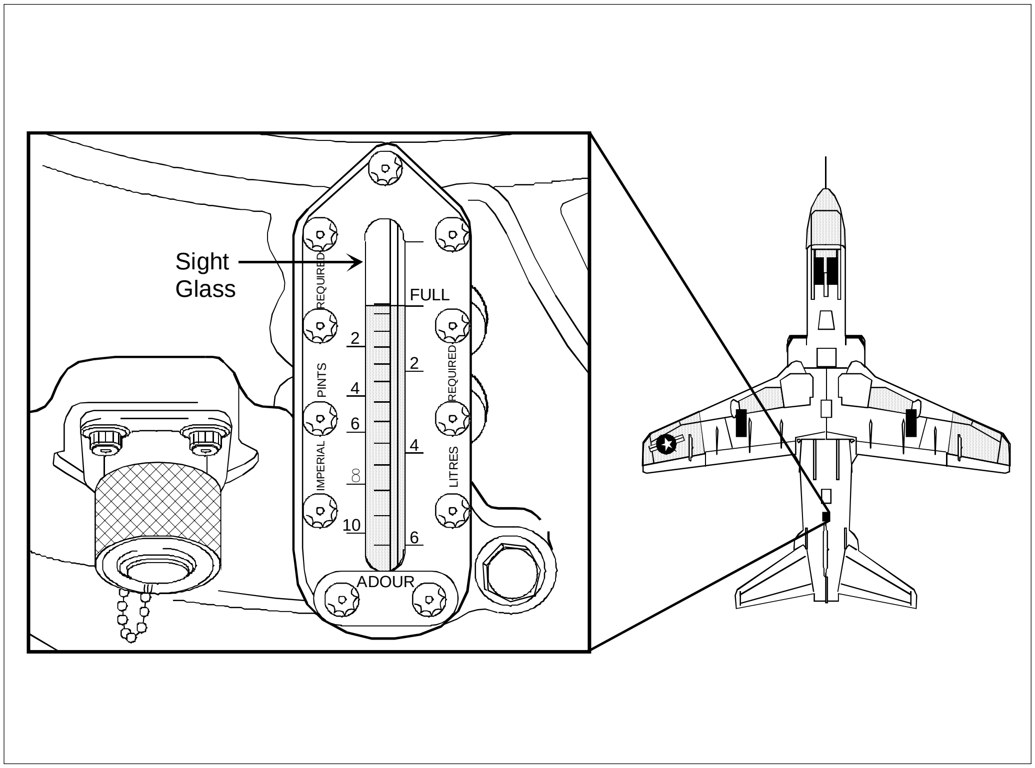


Figure 6: ENGINE OIL FILL GAUGE

1. Requirements: engine oil consumption and level

   NOTE: If the engine oil level is checked during preflight, the sight gauge readings will be higher than normal because of oil bleed-back from the engine. A low oil indication should be cause for concern.

   NOTE: The service check for engine oil should be completed no sooner than 5 minutes and no later than 30 minutes after engine shutdown (completely stopped) to avoid erroneous readings or possible over-servicing.

2. Evaluation criteria: oil level

    a. Minimum oil level for flight: 2 liters (4.2 U.S. pints) below FULL mark

    b. Maximum consumption: 0.8 pints per hour

3. Approved oil types

    a. MIL-L-23699C (primary)

    b. MIL-L-7808G (alternate)

4. GTS oil reservoir: check to ensure adequate supply of oil

V. Engine/aircraft interfaces **1.4.6.2**

A. Inputs

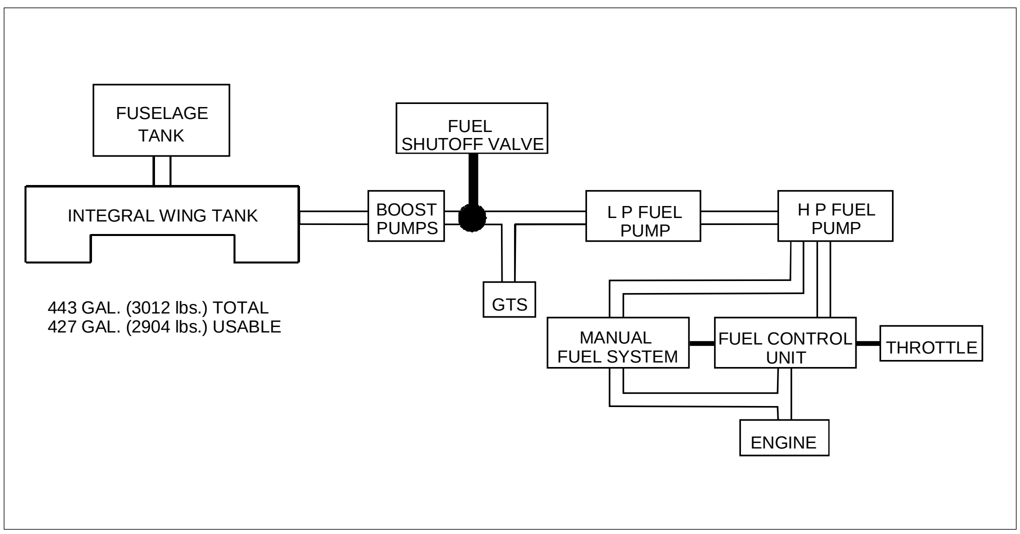


Figure 7: SIMPLIFIED FUEL SYSTEM BLOCK DIAGRAM

1. Fuel: aircraft fuel system

2. Mechanical: throttle controls

Sg 5, fr 2
Lesson Organization

ENGINE AND RELATED SYSTEMS

* Major components of the T-45C engine
* Engine operating characteristics
* Controls, switches, and indicators
* Engine servicing
* **Engine/aircraft interfaces**

Sg 5, fr 3
Fig 7: *Simplified Fuel System Block Diagram*

3. Electrical power: 28 VDC essential services bus from electrical system for engine igniters, ECA power and fuel control switching

B. Outputs

1. Air

a. OBOGS

b. ECS

c. Fuel tank pressurization

d. P1 probe anti-icing

2. Mechanical drive items: in addition to engine peculiar items (fuel and oil pumps)

a. Generator

b. HYD 1 and HYD 2 pumps

3. Electrical (sensing)

a. CWS signals

(1) Warning/caution

(a) FIRE

(b) GTS FIRE

(c) EGT/RPM

(d) OIL PRESS

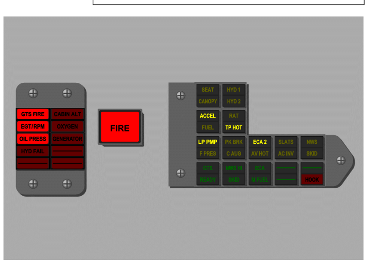
(e) TP HOT

(f) LP PMP

(g) ACCEL

(h) ECA 2

Sg 5, fr 4
Warning and Caution Advisory Light Panels



(2) Advisory

(a) GTS

(b) READY

(c) ECA

(d) M FUEL

b. Instruments

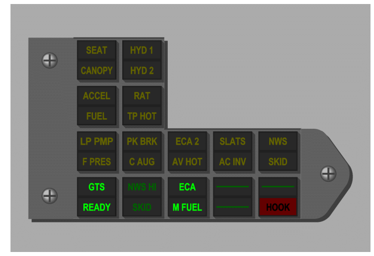
(1) EGT indicator

(2) RPM indicator

(3) FUEL FLOW indicator

(4) Engine Display MFD

Sg 5, fr 5
Caution Advisory Panel



Sg 5, fr 6
Primary Engine Instruments & MFD Engine Display

PROGRESS CHECK

Question 3 — 1.4.6.4
What is the maximum allowable oil consumption rate for the T-45C?

ANSWER: 0.8 U.S. pints per hour

Sg 6, fr 2
Review Menu

SUMMARY

This lesson focused on the following topics:

* Major components of the T-45C engine
* Engine operating characteristics
* Purpose, function, and location of T-45C engine system controls, switches, and indicators
* Engine servicing
* Interfaces between the engine and other T-45C systems

CONCLUSION

Knowing the engine system operation and recognizing the significance of cockpit indications are critical to completing your flight in a safe and professional manner.

LESSON GUIDE

COURSE/STAGE: TS, ADV, & IUT Engineering

LESSON TITLE: Engine and Related Systems Malfunctions

LESSON IDENTIFIER: T-45C TS, ADV, & IUT ENG-05

LEARNING ENVIRONMENT: CAI

ALLOTTED LESSON TIME: 1.4 hr

TRAINING AIDS:

Figures
Fig 1: Engine Components
Fig 2: Engine Fuel/Control System
Fig 3: Engine Oil System
Fig 4: Engine Starting System
Fig 5: Engine Operating Limitations
Fig 6: Indications of Engine Overtemp

STUDY RESOURCES:

* T-45C NATOPS Flight Manual, A1-T45AC-NFM-000
* T-45C NATOPS Pilot's Pocket Checklist, A1-T45AC-NFM-500

LESSON PREPARATION:

Read:

* Part I, Chapter 2, Section 2.1, “Engine System,” and Section 2.1.2, “Operation,” T-45C NATOPS Flight Manual, A1-T45AC-NFM-000
* Part I, Chapter 4, Section 4.2, “Engine Limitations,” T-45C NATOPS Flight Manual, A1-T45AC-NFM-000
* Part V dealing with engine and related systems malfunctions, T-45C NATOPS Flight Manual, A1-T45AC-NFM-000
* NATOPS Pilot’s Pocket Checklist, A1-T45AC-NFM-500

Review:

* Lecture Guide for Eng-04, “Engine and Related Systems”

REINFORCEMENT: N/A

LESSON EXAMINATION:

Student is required to read engine system and related malfunction paragraphs in the NATOPS Flight Manual, receive classroom instruction, and complete assigned CAI lesson(s). The student shall demonstrate knowledge by completing, from memory with 80% accuracy, true/false and multiple choice block examinations. The objectives in this lesson will be tested in either Engineering 29X or Engineering 30X.

LESSON OBJECTIVES

1.8.1.1.4.1
Identify indications of engine overtemp

1.5.3.1.5.2.1
Identify indications of reduced thrust on takeoff

1.5.3.1.5.4.1
Identify indications of engine failure on takeoff

1.5.3.1.5.1.1
Identify indications of engine fire during takeoff

1.8.1.1.1.1
Identify indications of engine fire at altitude (secondary indications)

1.8.1.1.2.1
Identify indications of engine fire (no secondary indications)

1.8.1.1.3.1
Identify indications of engine fire (light out with power reduction)

1.10.5.3.1.1
Identify indications of engine fire on shutdown

1.8.1.1.5.1
Identify indications of engine stalls

1.8.1.1.10.1
Identify indications of engine vibrations

1.8.1.1.7.1
Identify indications of engine overspeed

1.8.1.1.8.1
Identify indications of engine flameout

1.8.1.1.9.1.1
Identify indications of ECA failure (full trim)

1.8.1.1.9.2.1
Identify indications of ECA failure (no trim)

1.8.1.1.18.1
Identify indications of initial shot solenoid failure

1.8.1.1.19.1
Identify indications of steam ingestion bleed valve failure

MOTIVATION

Engine malfunctions, especially at critical stages of flight, must be recognized quickly and handled professionally. In the simulator you can expect emergencies and malfunctions, but in the aircraft they seem to occur at the most inopportune times. A fire warning light at lift-off indicates a malfunction that must be analyzed rapidly to determine if a fire really exists, so you can take the appropriate action. You certainly would not want to eject if the warning were erroneous.

You must be able to identify any aircraft system malfunction, respond with the correct procedures, and determine whether to continue the flight or abort. In addition, the more accurately you can describe a malfunction to maintenance, the more quickly the turnaround will be accomplished.

OVERVIEW

In this lesson, you will learn about malfunctions related to the engine system. Keep in mind that although these malfunctions are presented separately, two or more of them could coexist.

The goal of this lesson is to increase your ability to make the proper decisions when faced with an engine system malfunction. The knowledge you gain from this and other engineering lessons will enable you to make educated decisions that could enable the safe completion of a flight.

Later in the curriculum, you'll learn the precise emergency procedures.

This lesson presents cockpit and external indications of the following conditions:

* Engine overtemp
* Reduced thrust on takeoff
* Engine failure on takeoff
* Engine fire
* Engine stalls
* Engine vibrations
* Engine overspeed
* Engine flameout
* ECA failure (full trim)
* ECA failure (no trim)
* Initial shot solenoid failure
* Steam ingestion bleed valve failure

REFRESHER

Recall:

* Normal operation of the engine and related systems from Eng-04
* The location and function of T-45C cockpit engine indicators, warning and caution advisory panel, FIRE light, and MASTER ALERT light
* The T-45C Warning and Caution Advisory lights associated with the engine system

Fig 1: *Engine Components*
Fig 2: *Engine Fuel/ Control System*
Fig 3: *Engine Oil System*
Fig 4: *Engine Starting System*
Fig 5: *Engine Operating Limitations*

PRESENTATION

I. Engine overtemp **1.8.1.1.4.1**

Fig 6: *Indications of Engine Overtemp*

A. Indications

1. EGT reads above normal (over 610 degrees C)

   NOTE: The maximum transient temp is 645 degrees C for less than 20 seconds. (The CWS will activate when the temperature is 650 +/- 8 degrees C.)

2. MASTER ALERT flashes

3. Warning tone sounds

4. Warning panel: EGT/RPM light illuminates

   NOTE: The probable cause of this malfunction is an uncontrolled fuel flow due to a malfunctioning ECA. If this is the case, the ECA caution light will illuminate prior to the above-mentioned indications.

B. Verifications same as indications

C. Effects on flight safety

1. Possible engine/aircraft damage

2. Possible loss of thrust

3. Possible fire

II. Reduced thrust on takeoff **1.5.3.1.5.2.1**

NOTE: This malfunction may be caused by an engine bleed valve failure or a steam ingestion bleed valve failure (CWS indications) resulting in loss of thrust. A faulty ECA or intake icing could also cause reduced thrust at takeoff.

A. Indications

1. RPM low

2. EGT low

3. Slower than normal aircraft acceleration

4. Reduced climb performance

5. CWS

   a. Caution tone sounds

   b. MASTER ALERT flashes

   c. ACCEL caution light illuminates

B. Verifications

NOTE: It is not necessary that all of the following verifications be present to consider the indications confirmed.

1. Throttle at MRT position

2. RPM below normal

3. EGT below computed value

4. Fuel flow below normal value

5. Line speed not met

C. Effects on flight safety

1. Loss of thrust

2. Inability to attain flying speed

3. Inability to maintain flying speed

4. Possibility of total loss of thrust

III. Engine failure on takeoff **1.5.3.1.5.4.1**

A. Indications

1. Tactile: vibrations and sudden loss of acceleration

2. Aural: unusual noise followed by sound of engine winding down

B. Verifications

1. Engine rpm too low

2. EGT too low

3. Fuel flow too low

4. Difficulty in maintaining airspeed

C. Effects on flight safety

NOTE: If an abort is possible, the effects will vary depending on the amount of runway, density altitude, and the weight and speed of the aircraft. Prior to rotation, abort is required with possibility of a field arrestment.

1. Loss of thrust

2. Inability to maintain flight

3. Possible fire

4. Possible stall after rotation

IV. Engine fire **1.5.3.1.5.1.1, 1.8.1.1.1.1, 1.8.1.1.2.1, 1.8.1.1.3.1, 1.10.5.3.1.1**

A. Indications

1. Warning tone sounds

2. MASTER ALERT flashes

3. FIRE light illuminates

NOTE: The FIRE light may illuminate momentarily, then go out. This does *not* indicate the absence of a fire. It could mean, for example, that a fire has burned the wires carrying the signals that enable the FIRE light. It could also indicate a malfunction in the centralized warning system (i.e., a false indication). To verify that an engine fire does exist, secondary indications must be present.

B. Verifications

NOTE: Any or all of the following, in conjunction with the MASTER ALERT and FIRE lights, may be used to verify that an engine fire exists. The absence of secondary indications and the FIRE light extinguishing after throttle reduction could indicate a bleed air leak.

1. Any engine abnormality

    a. Rising or falling EGT

    b. RPM fluctuations

    c. Excessive fuel flow

    d. Smoke apparent in rear view mirrors

2. Warning and Caution Advisory lights

    a. EGT/RPM warning light illuminates

    b. TP HOT caution light illuminates

    c. OIL PRESS warning light illuminates

    d. HYD 1 caution light illuminates

    e. HYD 2 caution light illuminates

    f. RAT caution light illuminates

3. From external sources

    a. Plane captain/ground personnel via intercom system or hand signals (horizontal figure-eight motion)

    b. Tower

    c. Other aircraft

C. Effects on flight safety

1. Loss of aircraft

2. Serious engine/related components damage

3. Possible loss of control

4. Loss of thrust

5. Possible explosion

V. Engine stalls **1.8.1.1.5.1**

A. Indications

1. “Pop” or “bang” followed by a “buzzing” sound and vibrations

2. Lack of engine acceleration

B. Verifications

1. Sudden increase in EGT

2. Decrease in rpm

C. Effects on flight safety

The seriousness of the effects of this malfunction depends on its cause. An engine stall may warrant abort and landing as soon as possible. If the stall is “locked in” (unclearable) the engine must be shut down to prevent serious damage. Once shut down an airstart may be attempted depending on the situation and flight envelope.

1. Possible engine flameout

2. Possible loss of engine performance

3. Possible undetected engine damage

VI. Engine vibrations **1.8.1.1.10.1**

NOTE: Vibrations may be caused by the engine, engine accessories, flight controls, airframe, gear doors, or other components.

A. Indications

1. Tactile: vibrating airframe

2. Aural: rumbling or buzzing noise

B. Verifications

1. Reduce throttle to locate vibration range

2. Wingman inspects for abnormalities

C. Effects on flight safety

1. May indicate mechanical failure of internal engine parts, which could lead to engine failure

2. May indicate degradation or failure of other engine-driven accessories

VII. Engine overspeed **1.8.1.1.7.1**

NOTE: The max allowable N_2 rpm is 104% on rpm gauge. EGT/RPM warning light indicates N_1 rpm is above 112.4 +/- 1%.

NOTE: The T-45C is equipped with only an N_2 rpm gauge. N_1 rpm is only available on the MFD engine display along with N_2 rpm.

A. Indications

1. N_2--104% or above reading on rpm gauge

2. N_1

   a. MASTER ALERT light flashes

   b. Warning tone sounds

   c. EGT/RPM warning light illuminates

B. Verifications

1. Select ENGINE display

2. Verify N_1 rpm

C. Effects on flight safety

1. Could cause engine damage

2. Could cause engine overtemp

VIII. Engine flameout **1.8.1.1.8.1**

A. Indications

1. Loss of thrust

2. Engine winding down (rpm decreasing)

3. MASTER ALERT light flashes and warning tone sounds

4. Generator warning light illuminates

B. Verifications

1. Decreasing fuel flow

2. Decreasing EGT

3. Decreasing rpm

4. As rpm decreases, MASTER ALERT flashes

5. Warning/caution tone sounds

6. Appropriate warning and caution advisory panel lights illuminate

   a. GENERATOR warning light

   b. F PRES caution light

   c. OIL PRESS warning light

   d. HYD 1 caution light (windmilling engine may prevent light from illuminating)

   e. HYD 2 caution light

   f. C AUG caution light

   g. OXYGEN warning light

   h. CABIN ALT warning light (if altitude < 24,500 ft MSL)

   i. RAT caution light (when RAT extends)

C. Effects on flight safety

1. During airstart procedure, altitude and/or airspeed lost

2. After airstart, engine performance may be degraded

IX. ECA failure (full trim) **1.8.1.1.9.1.1**

NOTE: Loss of one of the dual ECA systems/lanes will cause the ECA advisory light to illuminate with no loss of performance. Loss of both ECA systems/lanes will cause the ECA advisory light and the ECA-2 caution light to illuminate, and you will lose automatic overspeed/overtemp control of the engine.

A. Indications

1. ECA advisory light

2. MASTER ALERT light

3. Caution tone sounds

4. ECA 2 caution light

B. Verifications
Depending upon current throttle settings:

1. RPM decreases
2. EGT decreases
3. Fuel flow decreases

NOTE: Thrust available will be governed by maximum RPM obtained. The thrust may be reduced by as much as one third of normal throttle value. Very low idle RPM may occur, and the throttle must be handled carefully to avoid stall or flameout.

C. Effects on flight safety

1. Limited throttle movement because sudden throttle movements may result in engine overspeed or overtemp
2. Possible reduction in thrust available may limit waveoff capabilities
3. RPM should not exceed 95 percent below 20,000 ft or 90 percent above 20,000 ft

X. ECA failure (no trim) **1.8.1.1.9.2.1**

A. Indications

1. MASTER ALERT light
2. Caution tone sounds
3. ECA 2 caution light

NOTE: The caution advisory panel indications for an ECA failure (no trim) are the same as for full trim ECA failure.

B. Verifications

1. RPM may increase
2. EGT may increase
3. Fuel flow may increase

C. Effects on flight safety

1. Limited throttle movement because sudden throttle movements may result in engine underspeed/overspeed, overtemp, or flameout
2. RPM should not exceed 95 percent below 20,000 ft or 90 percent above 20,000 ft

NOTE: If an ECA lane failure occurs, a momentary thrust fluctuation may be experienced. With a dual lane failure, engine EGT, fuel flow, and rpm should be monitored and the throttle carefully controlled. Manual fuel control use should be considered only if a dual lane failure is indicated and engine instability exists; for instance, stalls or surges.

XI. Initial shot solenoid failure **1.8.1.1.18.1**

A. Indications

1. MASTER ALERT light flashes

2. Caution tone sounds

3. ACCEL caution light illuminates

B. Verifications: Same as indications

C. Effects on flight safety

1. Above 9500 +/- 300 feet MSL - possible engine surge/stall due to rapid throttle movement

2. Below 7700 +/- 500 feet MSL - slow spoolup time due to reduced surge margin during rapid acceleration

3. Carrier landing <u>not permitted</u>

XII. Steam ingestion bleed valve failure **1.8.1.1.19.1**

A. Indications

1. MASTER ALERT light flashes

2. Caution tone sounds

3. ACCEL caution light illuminates

B. Verifications

1. Valve OPEN (Shore-based takeoff)

a. RPM may be lower than normal

b. EGT may be higher than normal

c. Slower than normal aircraft acceleration

d. Reduced climb performance

2. Valve CLOSED (Catapult takeoff) - Engine surge/stall due to steam ingestion

C. Effects on flight safety

1. Valve open

   a. Expect 10% reduction in MRT thrust

   b. Increased fuel consumption

2. Valve closed

   a. Possible engine surges/stall during catapult launch due to steam ingestion

SUMMARY

This lesson has presented indications, verifications, and effects on flight safety of these engine system malfunctions:

* Engine overtemp
* Reduced thrust on takeoff
* Engine failure on takeoff
* Engine fire
* Engine stalls
* Engine vibrations
* Engine overspeed
* Engine flameout
* ECA failure (full trim)
* ECA failure (no trim)
* Initial shot solenoid failure
* Steam ingestion bleed valve failure

CONCLUSION

The conditions described in this lesson might occur in conjunction with each other or with some malfunction related to another aircraft system.

If this lesson has raised any questions for you, be certain to contact your instructor.

FIGURES

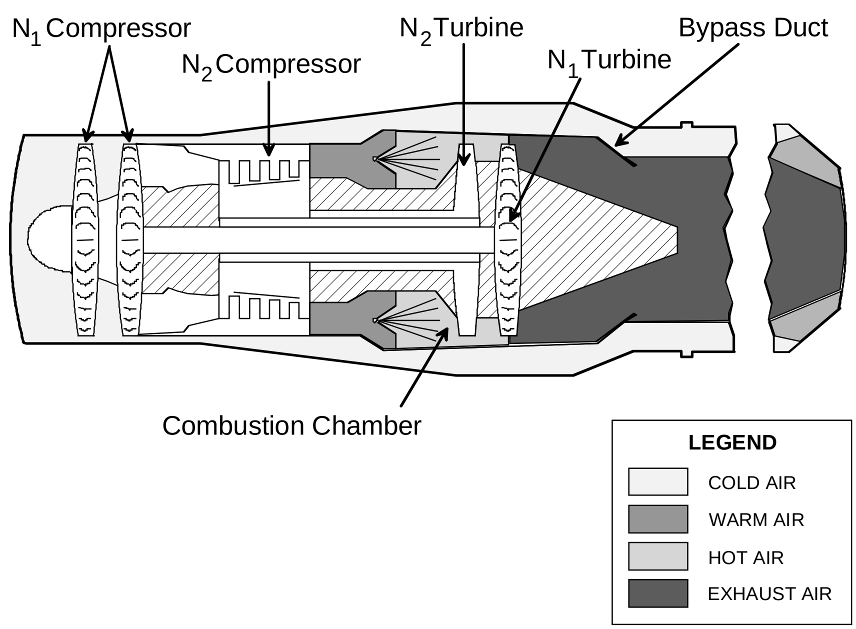


Figure 1: ENGINE COMPONENTS

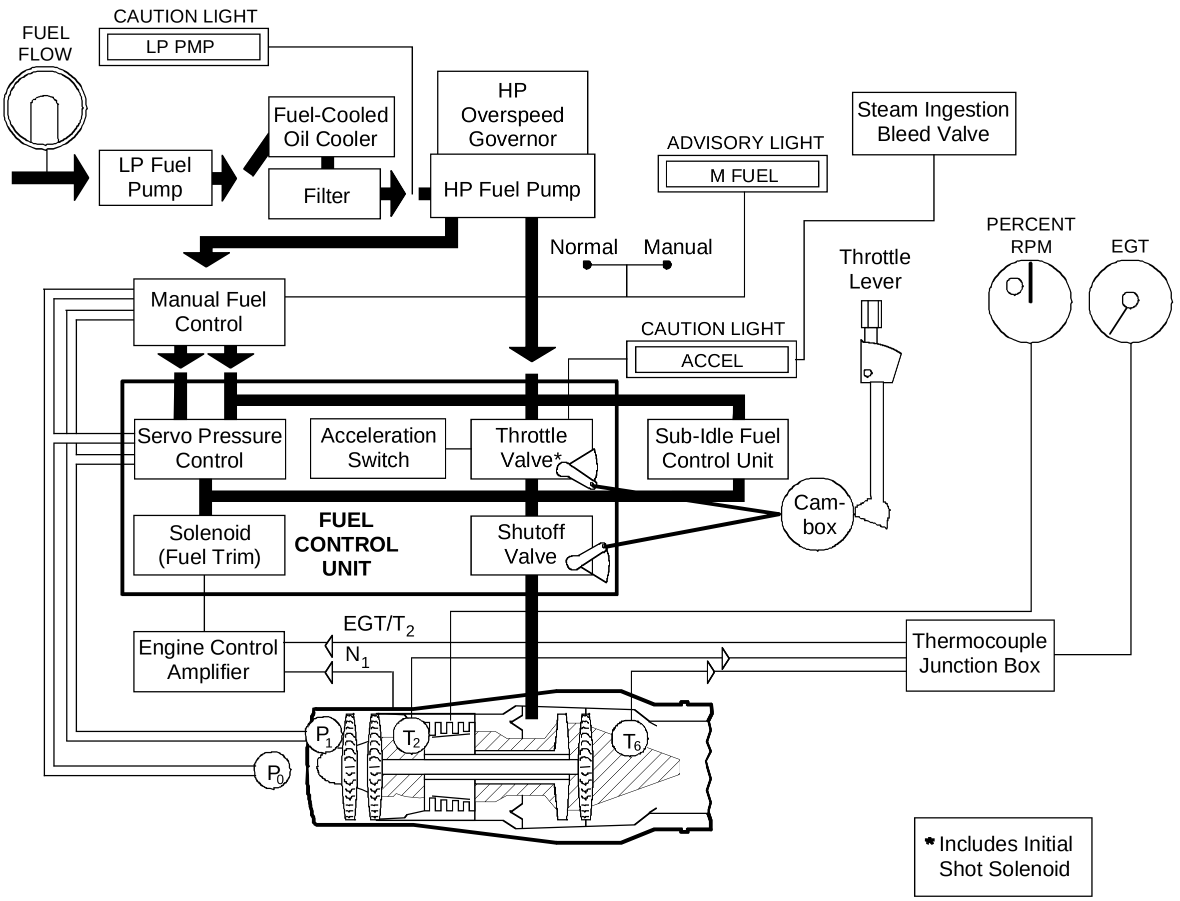


Figure 2: ENGINE FUEL/CONTROL SYSTEM

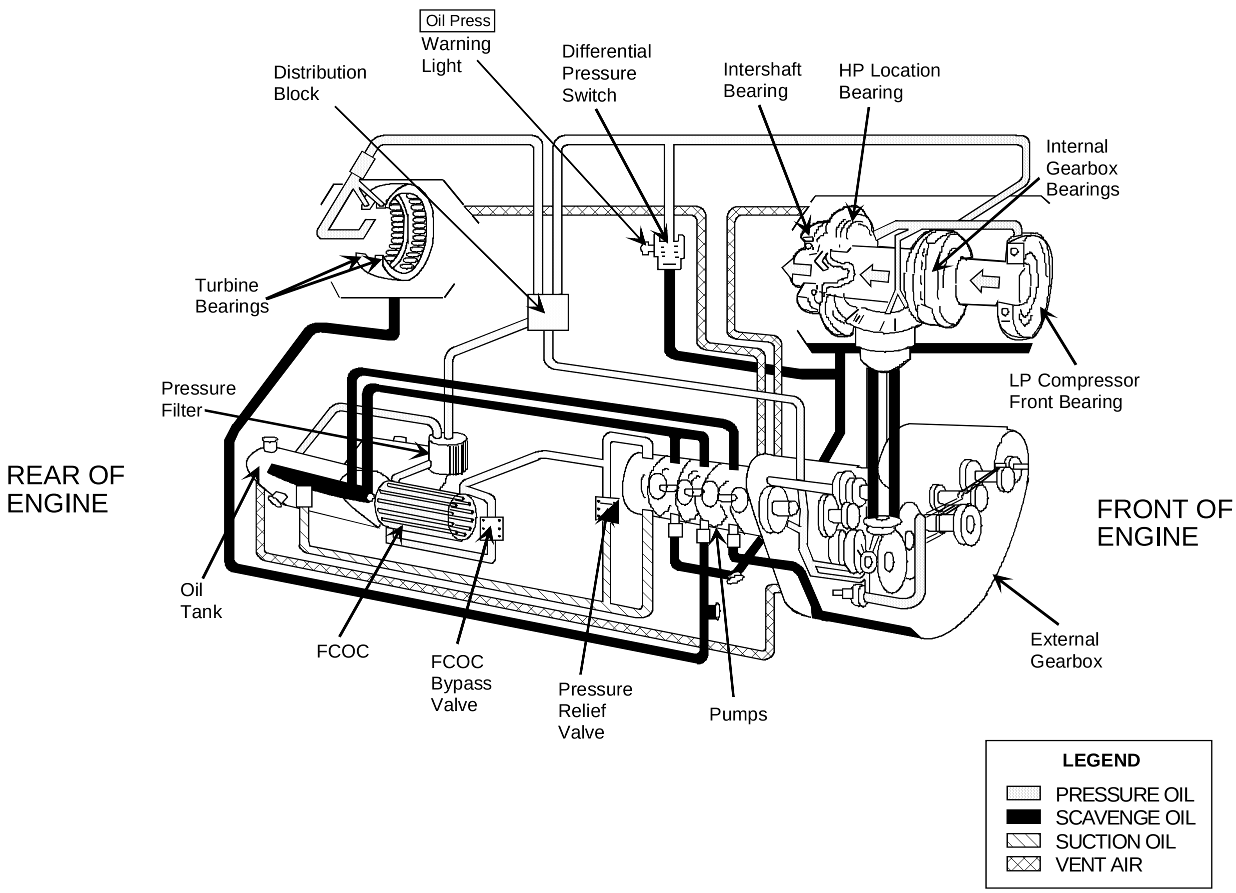


Figure 3: ENGINE OIL SYSTEM

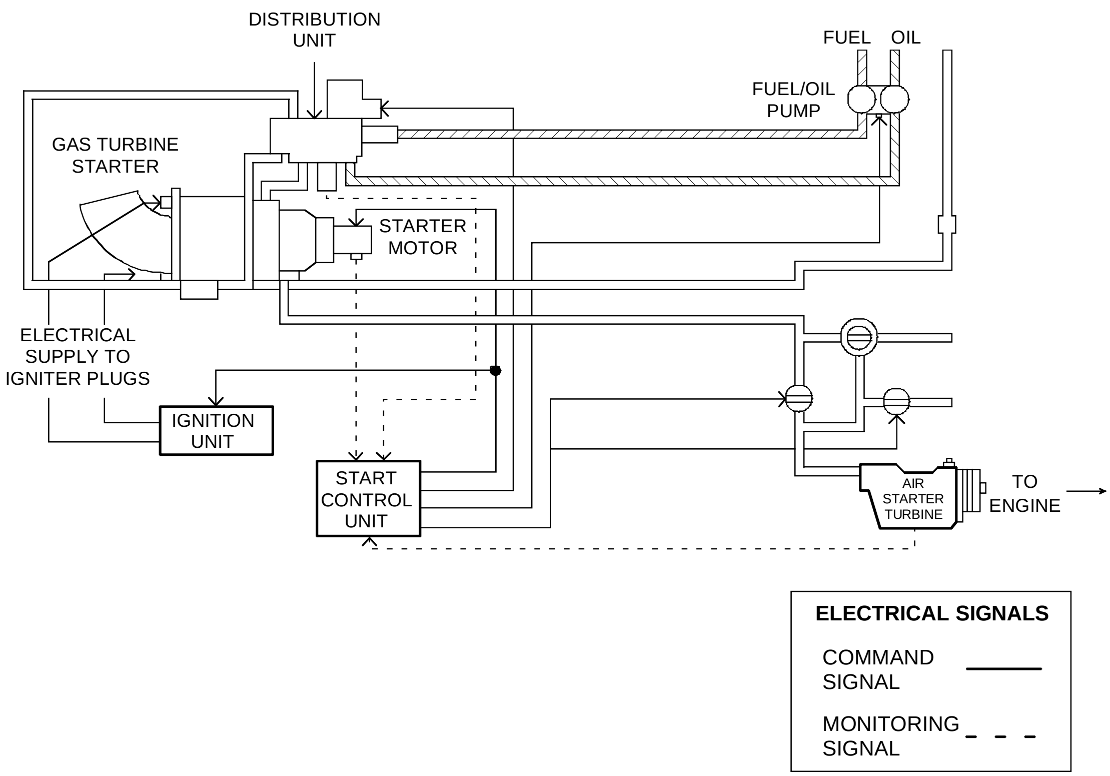


Figure 4: ENGINE STARTING SYSTEM

F 405-RR-401 OPERATING LIMITATIONS

CONDITION	MAXIMUM RPM (%)	MAXIMUM EGT (°C)	TIME LIMIT
Military Rated Thrust (MRT)	104	610	30 MIN/Flight Hour
Transient/Acceleration	104	645	Less than 20 sec
Maximum Continuous	100	550	--
Idle	55 ± 2 *(Note 1)*	450	--
Ground Start	--	550	*(Note 2)*
Airstart	--	600	*(Note 3)*

Notes:

1. *Bleed valve closed. This nominal RPM will vary depending on engine loading, air bleed, ambient conditions and altitude. Refer to NATOPS Flight Manual figure 4-2.*
2. *Maximum overshoot of 20°C for 10 seconds.*
3. *Maximum overshoot of 50°C for 10 seconds (the EGT/RPM warning light will operate at 650° ± 8°C).*
4. *Maximum shift in engine idle RPM between the Poststart and Engine Shutdown checks, corrected for standard day, is two percent.*

Figure 5: ENGINE OPERATING LIMITATIONS

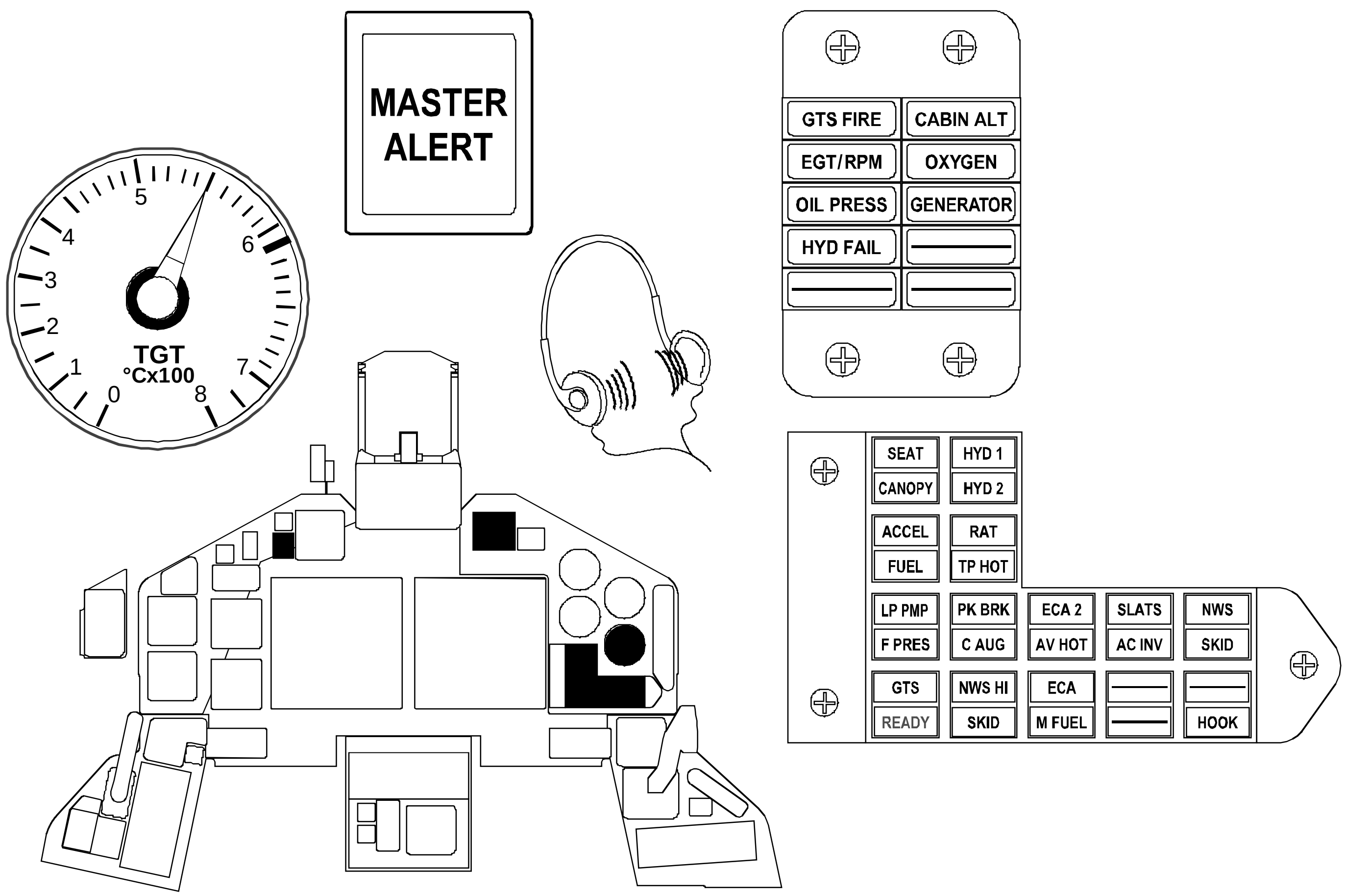


Figure 6: INDICATIONS OF ENGINE OVERTEMP

NOTES

LESSON GUIDE

COURSE/STAGE: TS, ADV & IUT / Engineering

LESSON TITLE: Engine System Malfunctions

LESSON IDENTIFIER: T-45C TS, ADV & IUT ENG-06

LEARNING ENVIRONMENT: CAI

ALLOTTED LESSON TIME: .7 hr

TRAINING AIDS:

* Figures:
  - Fig 1: Eng-05 Malfunction Indications and Verifications (Partial Listing)
  - Fig 2: Eng-05 Additional Malfunction Indications and Verifications
  - Fig 3: Tailpipe Overtemp
  - Fig 4: Engine Bleed Valve
  - Fig 5: LP Pump Failure
  - Fig 6: Oil Pressure Failure
  - Fig 7: Eng-06 Malfunction Indications and Verifications

STUDY RESOURCES:

* T-45C NATOPS Flight Manual, A1-T45AC-NFM-000
* T-45C NATOPS Pilot's Pocket Checklist, A1-T45AC-NFM-500

LESSON PREPARATION:

Read:

* Part I, Chapter 2, Section 2.1, “Engine System,” and Section 2.2, “Fuel System,” T-45C NATOPS Flight Manual, A1-T45AC-NFM-000
* Part I, Chapter 4, Section 4.2, “Engine Limitations,” T-45C NATOPS Flight Manual, A1-T45AC-NFM-000
* Part V, Chapter 12, “General Emergencies,” T-45C NATOPS Flight Manual, A1-T45AC-NFM-000
* NATOPS Pilot’s Pocket Checklist, A1-T45AC-NFM-500

Review:

* Lecture Guide for Eng-04, “Engine and Related Systems” and Lesson Guide for Eng-05, “Engine and Related Systems Malfunctions”

Bring:

* Lecture Guide for lesson Eng-04 and Lesson Guide Eng-05

REINFORCEMENT: N/A

LESSON EXAMINATION:

Student is required to read engine system and related malfunction paragraphs in the NATOPS Flight Manual, receive classroom instruction, and complete assigned CAI lesson(s). The student shall demonstrate knowledge by completing, from memory with 80% accuracy, true/false and multiple choice block examinations. The objectives in this lesson will be tested in either Engineering 29X or Engineering 30X.

LESSON OBJECTIVES

1.8.1.1.12.1
Identify indications of tailpipe overtemp

1.8.1.1.14.1
Identify indications of bleed valve failure (in flight)

1.8.1.1.13.1
Identify indications of engine icing

1.8.1.2.3.1
Identify indications of low pressure fuel pump failure

1.8.1.1.16.1
Identify indications of oil pressure failure

1.8.1.1.15.1
Identify indications of engine seizure

1.8.1.1.17.1
Identify indications of throttle linkage failure

1.9.3.14.1
Identify indications of stuck throttle

MOTIVATION

This lesson addresses the remainder of engine malfunctions. It will complete your understanding of the T-45C F405-RR-401 Engine System.

OVERVIEW

This lesson presents cockpit and external indications of the following conditions:

* Tailpipe overtemp
* Engine bleed valve failure (in flight)
* Engine icing
* Low pressure fuel pump failure
* Oil pressure failure
* Engine seizure
* Stuck throttle/throttle linkage failure

REFRESHER

Recall:

* Location and function of T-45C cockpit engine indicators, the warning and caution advisory panels, and MASTER light
* T-45C warning and caution advisory panel lights associated with engine system
* Indications and verifications of malfunctions presented in Eng-05

Fig 1: *Eng-05 Malfunction Indications and Verifications (Partial Listing)*

Fig 2: *Eng-05 Additional Malfunction Indications and Verifications*

PRESENTATION

I. Tailpipe overtemp **1.8.1.1.12.1**

A. Indications

Fig 3: Tailpipe Overtemp

1. MASTER ALERT flashes

2. Caution tone sounds

3. TP HOT caution light illuminates

B. Verifications--same as indications

C. Effects on flight safety

1. Airframe damage may result

2. Possible fire

3. Loss of thrust

4. High power settings could aggravate situation

II. Engine bleed valve failure (in flight) **1.8.1.1.14.1**

Fig 4: Engine Bleed Valve

A. Indications: significant loss of thrust

B. Verifications

1. Higher than normal throttle setting may be required to maintain flight parameters

2. EGT may rise

3. RPM lower than normal

C. Effects on flight safety: performance and altitude capabilities reduced

III. Engine icing **1.8.1.1.13.1**

A. Indications

NOTE: Degraded engine performance can result from ice obstructing the intakes

1. Loss of thrust

2. Possible surging and chugging

3. Probable increase in EGT

4. Loss of airspeed

B. Verifications: visually check for ice accumulation on intakes/airframe

C. Effects on flight safety

NOTE: Departure from icing conditions should soon restore the engine to normal operation.

1. Engine performance degraded

2. Engine stall possible

3. Engine damage possible

Fig 5: *LP Pump Failure*

IV. Low pressure fuel pump failure **1.8.1.2.3.1**

A. Indications

1. MASTER ALERT flashes

2. Caution tone sounds

3. LP PMP caution light illuminates

B. Verifications--same as indications

C. Effects on flight safety

1. High pressure fuel pump cavitation possible

2. Abrupt throttle movements may cause flameout

3. Unusual attitudes may cause flameout

Fig 6: *Oil Pressure Failure*

V. Oil pressure failure **1.8.1.1.16.1**

A. Indications

1. MASTER ALERT flashes

2. Warning tone sounds

3. OIL PRESS warning light illuminates

B. Verifications

NOTE: T-45C is not equipped with oil pressure gauge.

1. OIL PRESS warning will illuminate
2. Possible aircraft vibration if malfunction causes bearing failure
3. Wingman may see leaking oil or smoky exhaust

C. Effects on flight safety

1. Damage to engine
2. May cause engine overtemp
3. May cause engine seizure

VI. Engine seizure **1.8.1.1.15.1**

A. Indications

1. MASTER ALERT flashes
2. Warning tone sounds
3. Engine rotation stops
4. Loss of thrust (jolt felt if violent or sudden seizure)

B. Verifications

1. Engine rpm 0%
2. Warning and caution advisory light panels illuminated
   a. GENERATOR warning light
   b. OIL PRESS warning light
   c. HYD 1 caution light
   d. HYD 2 caution light
   e. F PRES caution light
   f. LP PMP caution light
   g. C AUG caution light
   h. Other lights as systems shut down
3. RAT will extend

C. Effects on flight safety

1. Airstart impossible
2. Total loss of thrust
3. Loss of OBOGS
4. Loss of pressurization/air-conditioning
5. Loss of HYD 1
6. Loss of generator
7. Max range gliding distance severely reduced

VII. Stuck throttle/throttle linkage failure **1.8.1.1.17.1 1.9.3.14.1**

A. Indications

1. Throttle does not move
2. Throttle moves with no effect on rpm

B. Verifications

1. Throttle damper (friction) not too tight for movement
2. Movement of throttle in other cockpit has same effect

C. Effects on flight safety

1. Loss of thrust control
2. Airspeed management by attitude/drag control (speed brakes, flaps, slats, and/or gear)

SUMMARY

This lesson has presented indications of these engine and related system malfunctions:

* Tailpipe overtemp
* Engine bleed valve failure (in flight)
* Engine icing
* Low pressure fuel pump failure
* Oil pressure failure
* Engine seizure
* Stuck throttle/throttle linkage failure

Fig 7: *Eng-06 Malfunction Indications and Verifications*

CONCLUSION

Being able to recognize aircraft system malfunctions quickly is critical to making safe and logical decisions in an emergency.

If this lesson has raised any questions for you, be certain to contact your instructor.

FIGURES

MALFUNCTION	CAUTION LIGHTS	WARNING LIGHTS	TONE	OTHER
Engine Overtemp, Overspeed		EGT/RPM	Warning	MASTER ALERT Light Abnormal EGT Abnormal RPM
Reduced Thrust on Takeoff	ACCEL (possible)		Caution (possible)	Low RPM Low EGT Line Speed Not Met Slow Acceleration Reduced Climb Performance Low Fuel Flow Throttle at MRT
Engine Failure on Takeoff				TACTILE: - Sudden Loss of Acceleration AURAL: - Unusual Noise or Vibration RPM Too Low EGT Too Low Fuel Flow Too Low Unable to Maintain Speed
Engine Fire	HYD 1&2 TP HOT AC INV C AUG ECA 2 RAT	FIRE Light EGT/RPM OIL PRESS GENERATOR	Warning	MASTER ALERT Light Rising or Falling EGT RPM Fluctuations Excessive Fuel Flow Visible Smoke or Fire Erratic or Rough Engine

Figure 1: ENG-05 MALFUNCTION INDICATIONS AND VERIFICATIONS (PARTIAL LISTING)

MALFUNCTION	CAUTION LIGHTS	WARNING LIGHTS	TONE	OTHER
Engine Stalls				Loud Banging or Popping Noises Lack of Acceleration High EGT Decrease in RPM
Engine Vibrations				Feel Airframe Vibrating Hear Rumbling or Buzzing Noise
Engine Overspeed N_1		EGT/RPM	Warning	N_1: RPM Above 108% MASTER ALERT Light
N_2				N_2: RPM Above 104%
Engine Flameout	HYD 2 F PRES RAT C AUG	GENERATOR OIL PRESS	Caution Warning	Feel Loss of Thrust No Response to Throttle Hear Engine Winding Down MASTER ALERT Light Fuel Flow, EGT, and RPM Decrease Rat Extends
ECA Failure--Full Trim	ECA 2		Caution	MASTER ALERT Light RPM, EGT, and Fuel Flow Decrease
ECA Failure--No Trim	ECA 2		Caution	MASTER ALERT Light RPM, EGT, and Fuel Flow May Increase
Initial Shot Solenoid Failure	ACCEL		Caution	MASTER ALERT Light Slow Throttle Response During Approach
Steam Ingestion Bleed Valve Failure	ACCEL		Caution	MASTER ALERT Light Engine Surge on Catapult Shot 10% Reduction of MRT Thrust

Figure 2: ENG-05 ADDITIONAL MALFUNCTION INDICATIONS AND VERIFICATIONS

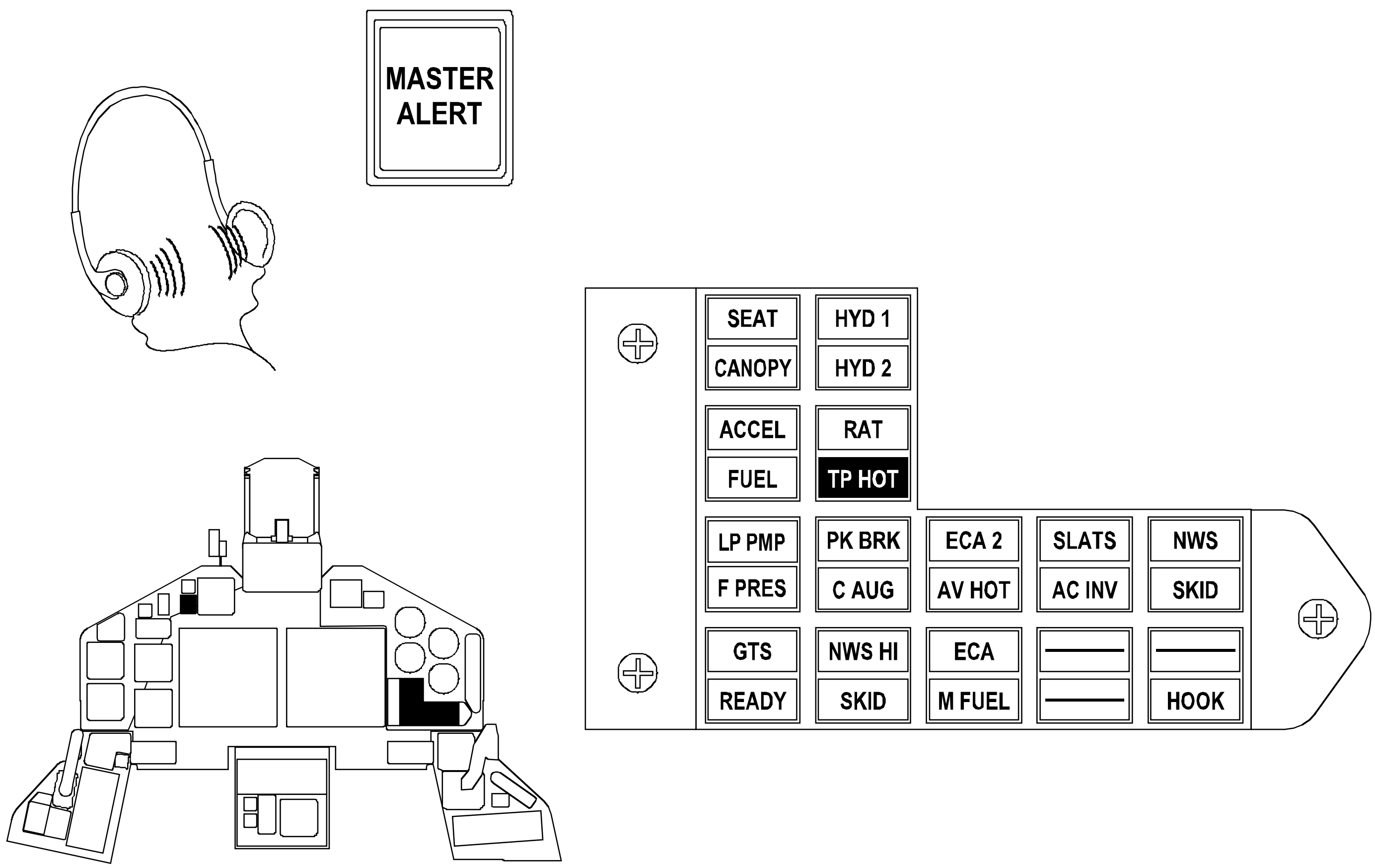


Figure 3: TAILPIPE OVERTEMP

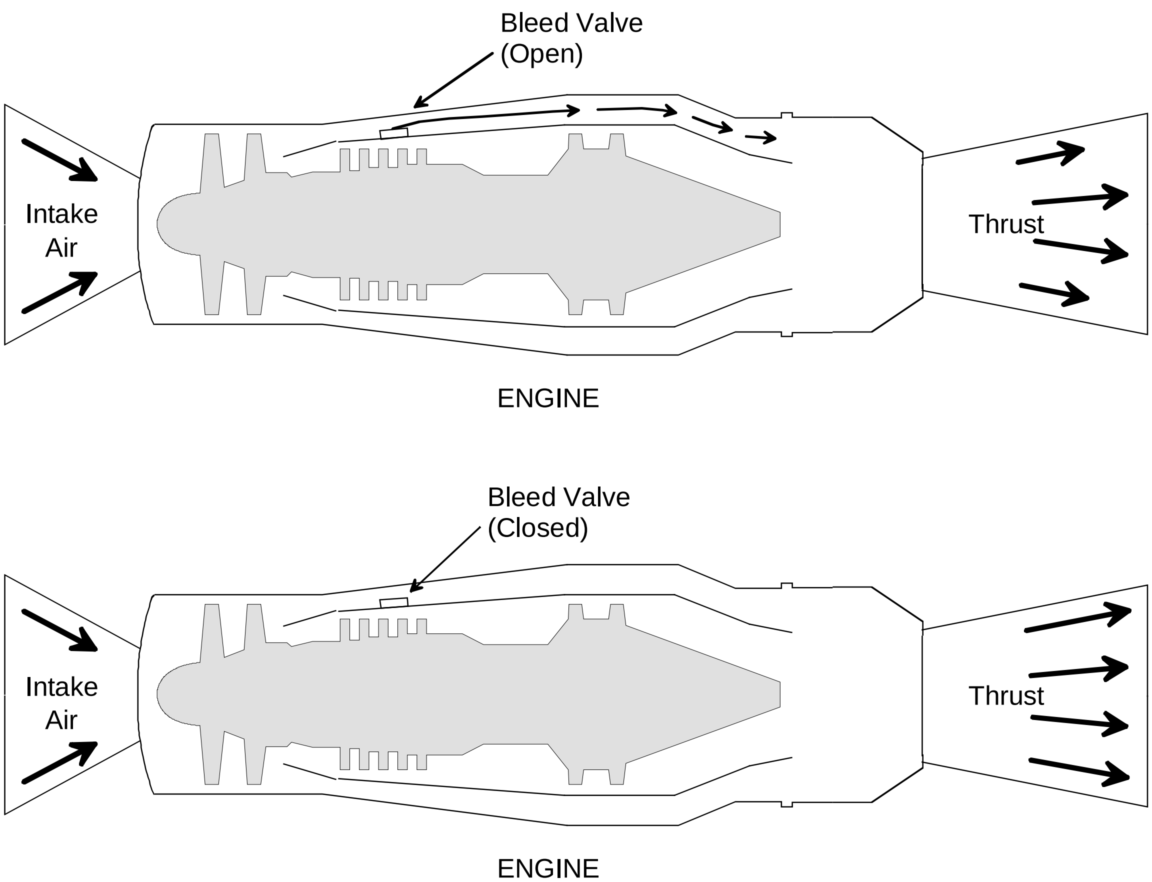


Figure 4: ENGINE BLEED VALVE

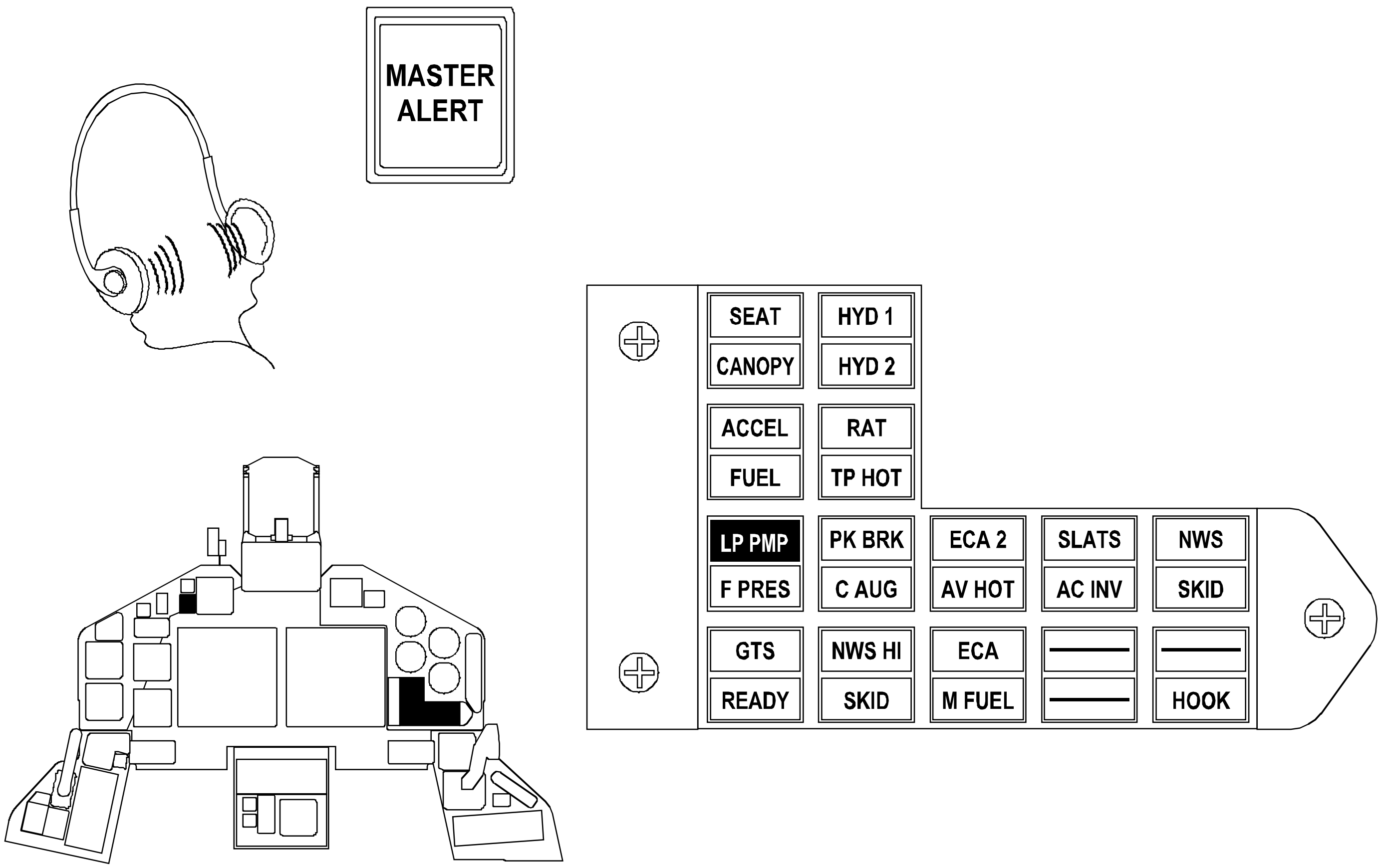


Figure 5: LP PUMP FAILURE

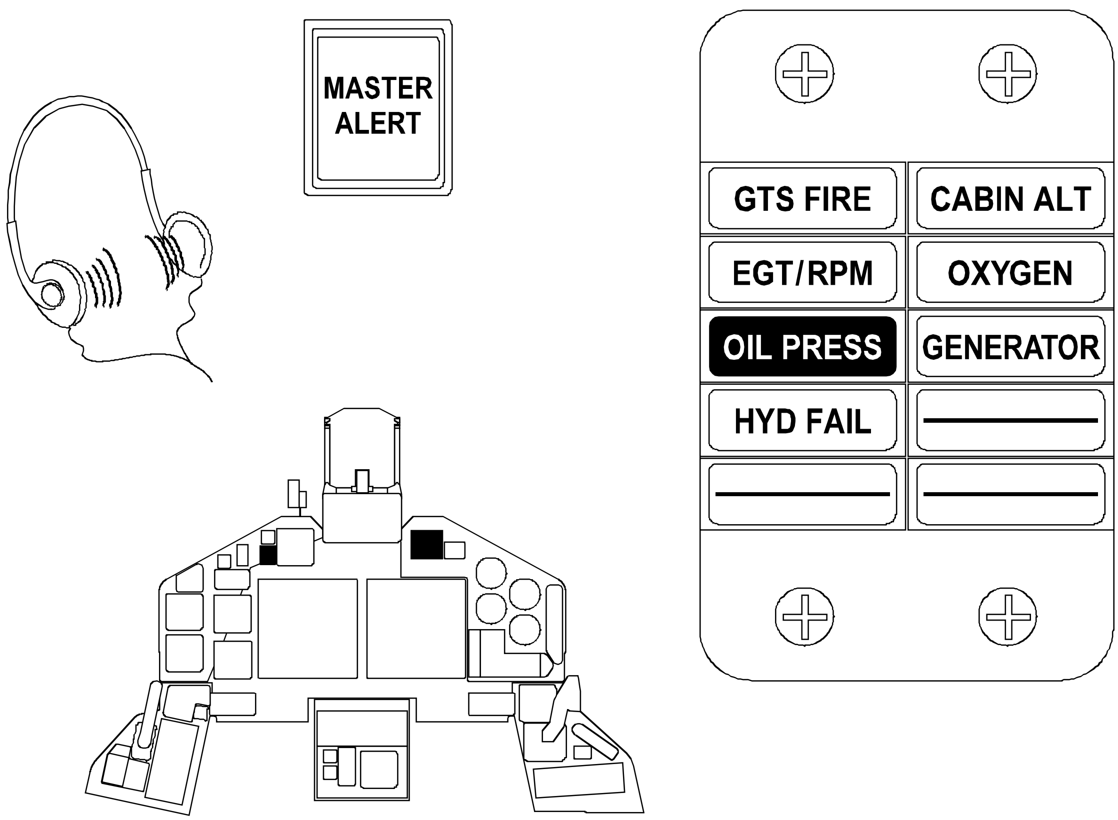


Figure 6: OIL PRESSURE FAILURE

MALFUNCTION	CAUTION LIGHTS	WARNING LIGHTS	TONE	OTHER
Tailpipe Overtemp	TP HOT		Caution	MASTER ALERT Light
Bleed Valve Failure (in flight)				Loss of Thrust Higher Than Normal Throttle Setting EGT May Rise RPM May Be Lower Than Normal
Engine Icing				Loss of Thrust Possible Surging and Chugging Probable Increase in EGT Loss of Airspeed Accumulation of Ice on Intakes/ Airframe
Low Pressure Fuel Pump Failure	LP PMP		Caution	MASTER ALERT Light
Oil Pressure Failure		OIL PRESS	Warning	MASTER ALERT Light Aircraft May Vibrate Leaking Oil or Smoky Exhaust
Engine Seizure	AC INV HYD 1 HYD 2 F PRES	GENERATOR OIL PRESS	Warning Caution	MASTER ALERT Light Engine Rotation Stops (RPM 0%) Total Loss of Thrust RAT Extends
Stuck Throttle/ Throttle Linkage Failure				Throttle Will Not Move Throttle Moves But Has No Effect on RPM Throttle Damper Not Too Tight Throttle in Other Cockpit Has Same Indications

Figure 7: ENG-06 MALFUNCTION INDICATIONS AND VERIFICATIONS

LECTURE GUIDE

COURSE/STAGE: TS, ADV & IUT / Engineering

LESSON TITLE: Aircraft Fuel System

LESSON IDENTIFIER: T-45C TS, ADV & IUT ENG-07

LEARNING ENVIRONMENT: Classroom

ALLOTTED LESSON TIME: 0.9 hr

TRAINING AIDS:

* Figures
  - Fig 1: Simplified Fuel System Block Diagram
  - Fig 2: Aircraft Fuel System Block Diagram
  - Fig 3: Fuel System Status Advisory Indications
  - Fig 4: Fuel System Caution Advisory indications
  - Fig 5: Fuel System Controls (Forward Cockpit Only)

STUDY RESOURCES:

* <u>T-45C NATOPS Flight Manual</u>, A1-T45AC-NFM-000

LESSON PREPARATION:

Read:

* Part 1, Chapter 2.2, "Fuel System," in the T-45C NATOPS Flight Manual, A1-T45AC-NFM-000

REINFORCEMENT: N/A

EXAMINATION:

Student is required to read fuel system paragraphs in the NATOPS Flight Manual, receive classroom instruction, and complete assigned CAI lesson(s). The student shall demonstrate knowledge by completing, from memory with 80% accuracy, true/false and multiple choice block examinations. The objectives in this lesson will be tested in either Engineering 29X or Engineering 30X.

LESSON OBJECTIVES

1.4.7.3.1
Recall major components of the fuel system

1.4.7.2.1
Recall operating characteristics of the fuel system

1.4.7.3
Recall function and location of fuel system controls, switches, and indicators

1.4.7.2
Recall interfaces between the fuel system and other a/c systems

MOTIVATION

Properly managing the T-45C fuel system ensures your fuel supply is adequate to complete your flight.

OVERVIEW

In this lesson we will be covering:

* Aircraft fuel system major component identification
* Operational characteristics
* Controls, switches, and indicators
* Aircraft interfaces

REFRESHER

Sg 0, fr 5
***Fig 1:** Simplified Fuel System Block Diagram*

* This lesson builds on your knowledge of the T-45's fuel system gained in Eng-04. In Eng-07, we will explore the aircraft fuel system as opposed to the engine fuel system.

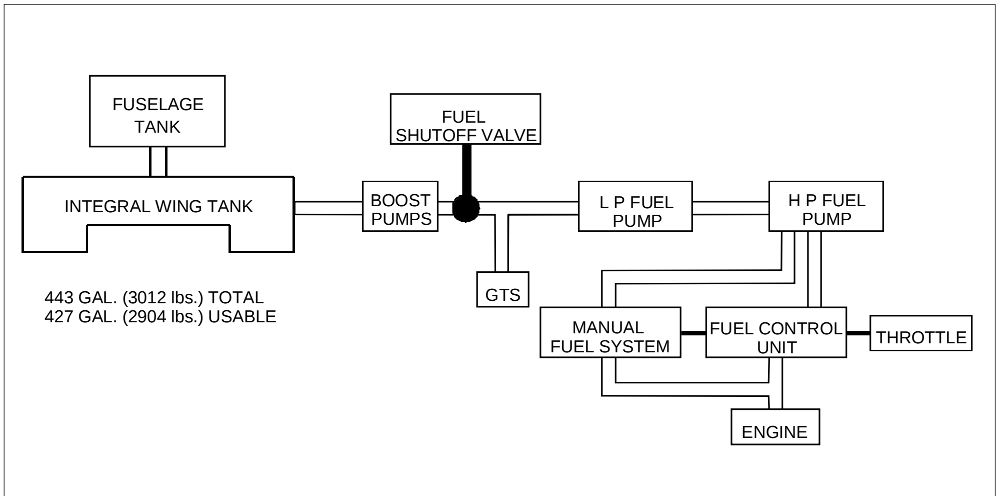


Figure 1: SIMPLIFIED FUEL SYSTEM BLOCK DIAGRAM

PRESENTATION

?

Name basic aircraft fuel system components and describe their general functions.

ANSWER: Aircraft fuel tanks are normally located both in the wings and in the fuselage. A transfer system (operated electrically and/or mechanically) routes fuel to a central point for further routing to the engine. Fuel system gauges indicate rate of fuel flow and fuel remaining. Refueling is normally accomplished by pressure and/or gravity methods.

Sg 1, fr 2
Lesson Organization

FUEL SYSTEM
* **Major component identification**
* Operational characteristics
* Controls, switches, and indicators
* Aircraft interfaces

Sg 1, fr 4
(10 Overlays)
***Fig 2:** Aircraft Fuel System Block Diagram*

Overlay 1
Fuselage Tank

I. Aircraft fuel system major component identification **1.4.7.3.1**

A. Fuel tanks

NOTE: The T-45C has a total fuel capacity of 443 U.S. gallons rated at 3012 lb JP-5 total (2904 lb JP-5, 2776 lb JP-4, JP-8 2861 usable).

1. Fuselage tank

a. Location: between the two engine intakes, just aft of the cockpit

b. Physical description

(1) Baffled, rubberized bag tank, hung inside fuselage (not a self-sealing tank)

(2) Fitted for plumbing connections

(a) Gravity filler cap

(b) Pressure control valve

(c) Vent/pressurization lines

(d) Fuel transfer lines

(e) Capacitance-type fuel quantity indicating system

(3) Capacity: approximately 220 gallons (1500 lb)

Overlay 2
Integral Wing Tank

2. Integral wing tank

a. Location: Between the front and rear spars on each side of the center line

b. Physical description

(1) Formed by wing surface above and below (wet wings and is not a self-sealing tank)

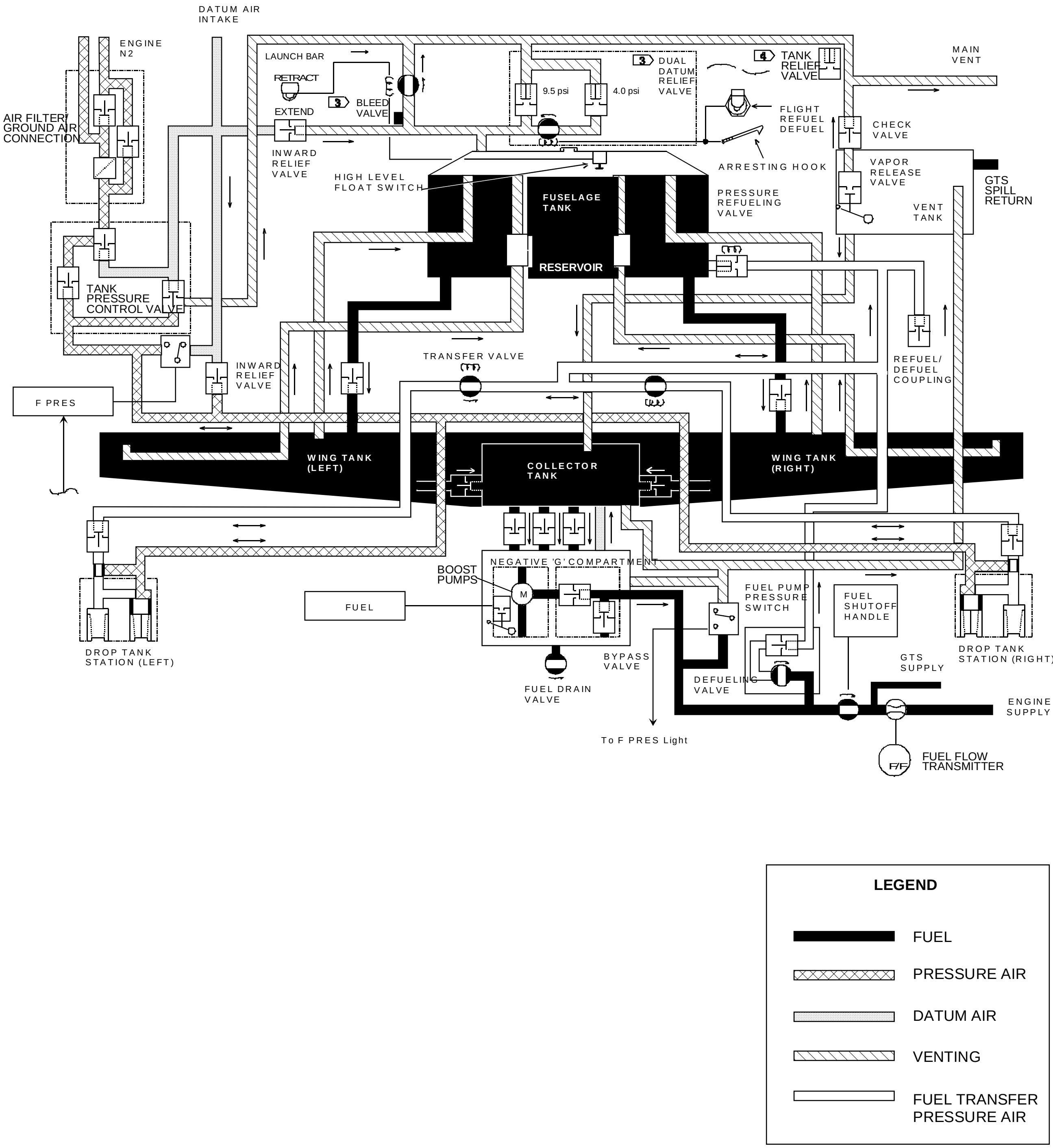


Figure 2: AIRCRAFT FUEL SYSTEM BLOCK DIAGRAM

(2) Wing ribs with holes provide transfer and baffling

(3) Fuel drain valves on underside of wing

(4) Water drain valves on underside of wing negative-G compartment

(5) Capacity: approximately 223 gallons (1540 lb), including collector tank with negative-g compartment

3. Collector tank

Overlay 3
Collector Tank

a. Location: center compartment of the wing tank

b. Physical description

(1) Separated from wing tank by diaphragms

(2) Spring loaded check valve on each side permit fuel flow from the wing tank

(3) Capacity: 60 gallons (approximately 400 lb), including negative-g compartment

c. Functional description: sump into which fuel feeds from wing tank

Overlay 4
Negative-G Compartment

4. Negative-g compartment

a. Location: forward part of the collector tank

b. Physical description

(1) Bounded by front spar

(2) Three integral flap-type valves permit fuel flow from collector tank

c. Functional description: contains enough fuel for 30 seconds of inverted flight

Overlay 5
Boost Pumps

B. Fuel delivery

1. Boost pumps

a. Location

(1) Two boost pumps are mounted on a manifold and installed in the negative-G compartment of the wing tank

b. Physical description

(1) Upper and lower body with interposing main bearing assembly bolted together (houses and supports motor)

(2) Filter-protected inlet at each end

(3) Electrically controlled and operated

c. Functional description

(1) Provides fuel under pressure to LP pump during all aircraft maneuvers

(2) Required during engine start because engine-driven fuel pumps only marginally capable of providing suction while at low speed

(3) A time delay will take the electric fuel boost pumps off line 30 seconds after loss of aircraft generator

(4) Receives electrical power from the 28 VDC essential services bus through 30-sec delay relay powered by the generator bus

(5) Fuel system feeds the engine LP pump for initial fuel supply

Overlay 6
Engine Fuel Supply

2. Engine fuel supply

   a. Location: flow from negative-g compartment boost pumps to bypass valve to fuel shutoff valve to engine

Overlay 7
GTS Fuel Supply

3. GTS fuel supply

   a. Location: downstream of fuel shutoff valve

   b. Physical description

      (1) Branch pipe from main fuel line

      (2) Connected to filter, shutoff valve, and combined fuel/oil pump

Overlay 8
Vent Tank

C. Venting

1. Vent tank

   a. Location: mounted in GTS bay above engine

   b. Functional description: assists in transfer of air and fuel vapors from collector tank to atmosphere; allows condensed fuel and surplus GTS fuel to drain back into collector tank

Overlay 9
Main Vent

2. Main vent

   a. Location: upper left side of tail cone

   b. Physical description: large outlet line from vent tank

Overlay 10
Refueling Coupling

D. Refueling

1. Pressure refueling coupling

   a. Location: access door left air intake fairing

   b. Physical description: self-sealing valve assembly with bayonet flange

2. Gravity filler cap

   a. Location: access panel top left side of fuselage, aft of the cockpit

   b. Physical description: lift-and-turn-to-unlock filler cap

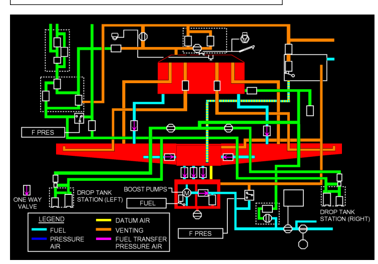
II. Operational characteristics **1.4.7.2.1**

Sg 2, fr 2
Lesson Organization

FUEL SYSTEM

* Major component identification
* **Operational characteristics**
* Controls, switches, and indicators
* Aircraft interfaces

Sg 2, fr 3 (3 Overlays)
Aircraft Fuel System Block Diagram



A. Pressurization

1. Normal operations

   a. Function

      (1) Suppresses tendency of fuel to boil at high altitudes

      (2) Aids in transfer of fuel

      (3) Keeps collector tank full

   b. Operational description

      (1) Fed by bleed air from high pressure fifth stage of the high pressure compressor

      (2) Filtered and regulated to 6 psi above ambient by tank pressure control valve

      (3) Pressure air supply is connected to fuel transfer line at pylon fuel/air valve to pressurize fuel tanks

      NOTE: The pylon fuel/air valves would also provide pressure for fuel transfer of external fuel into fuselage bag in the event of future installation of drop tanks.

      (4) Dual datum relief valve prevents overpressure damage to fuel tanks and structure

(5) Air pressure switch senses pressurization loss

(6) Datum air (RAM air)

(a) Enters through inward venting line protruding through fuselage right skin

(b) Provides air pressure slightly above ambient pressure to maintain pressurization at positive value

Overlay 1
Fuel Delivery

B. Fuel delivery

1. Normal operations

a. Function: provides fuel to GTS and engine fuel system

b. Operational description

(1) Refueling access door closed—refueling switch held in FLIGHT position

(2) Internal tanks

(a) Fuel level in fuselage tank falls as fuel is drawn from negative-g compartment

(b) Pressurized air aids gravity in fuel transfer to wing tank

(c) Wing tank feeds collector tank, collector tank feeds negative-g compartment

(d) Fuel from negative-g compartment supplies GTS and engine

(3) Check valves prevent reverse flow during aircraft maneuvers

NOTE: The flap-type check valves prevent reverse fuel flow within the negative-g tank. Boost pumps, provide positive fuel flow to the engine during negative-g and inverted flight maneuvers.

C. Venting

Overlay 2
Venting

1. Normal operations

a. Function

(1) Releases air/vapor to atmosphere through pressure relief and bleed valves

(2) Maintains full collector tank until all internal fuel is used

b. Operational description: outward venting

(1) Collector tank

(a) Two lines, one from collector tank and one from negative-g compartment, vent air or vapor to vent tank

(b) Condensed fuel returns to collector tank from vent tank

(2) Integral wing tank

(a) Two vent lines connect to and terminate in upper part of fuselage tank

(b) Two smaller lines vent outboard ends of tanks through two small reservoirs in lower part of fuselage tank

(3) Fuselage tank

(a) Vented to atmosphere through dual-setting pressure relief valve and an electrically operated bleed valve

(b) Normal pressure relief occurs at pressure in excess of 9.5 psi

(c) Reduced pressure relief of 4.0 psi when FLIGHT/REFUEL/DEFUEL switch is set to REFUEL or tail hook is down

(d) Bleed valve is electrically held closed when the fuselage tank is full and when the launch bar is not retracted with weight on wheels (to prevent venting of fuel during catapult launch)

(4) External fuel vent is located on upper left side of the tail cone

c. Operational description: inward venting

(1) An inward venting (ram air) line protrudes through right side of fuselage

(2) Provides datum air (ram air) inward venting, if tank pressurization fails

Overlay 3
Refueling

D. Refueling

1. Acceptable fuels (no adjustment to fuel control required)

a. Grade JP-5

b. Grade JP-4

c. Jet A+, Jet A-1+

2. Pressure refueling operation

   a. Location: access door engine left air intake fairing

      (1) Door open: three-position switch automatically set to REFUEL

      (2) Door closed: FLIGHT position automatically selected

      (3) Defuel position can be selected manually

   b. Refueling valve

      (1) Location: bottom of fuselage tank

      (2) Solenoid-operated

      (3) Receives electrical power from 28 VDC ground services bus (either battery or ground power)

   c. Fuel distribution

      (1) Through refueling valve to fuselage tank

      (2) Through fuselage tank to wings when fuel level covers transfer lines

   d. Pressure not to exceed 50 psi and flow rate not to exceed 180 GPM

   e. Displaced air

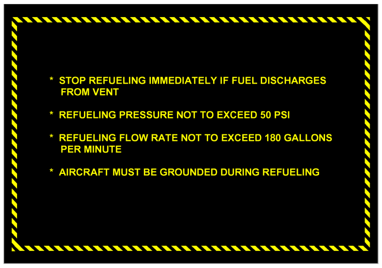
      (1) Rises to top of fuselage tank

      (2) Vented to atmosphere through main vent

Sg 2, fr 7
Video: *Refueling Access Door*

Sg 2, fr 9
Video: *Refueling Panel*

Sg 2, fr 12
Safety Warnings



Sg 3, fr 2
Lesson Organization

FUEL SYSTEM

* Major component identification
* Operational characteristics
* **Controls, switches, and indicators**
* Aircraft interfaces

Sg 3, fr 3
Fig 3: *Fuel System Status Indications*

3. Gravity refueling operation

   a. Location: capped filler on top of fuselage tank

4. Safety warnings

   a. Refueling must be stopped immediately if fuel is discharged through main vent above tail cone

   b. Refueling pressure not to exceed 50 psi

   c. Refueling flow rate not to exceed 180 US gallons per minute

   d. Aircraft must be grounded during refueling procedures

III. Controls, switches, and indicators **1.4.7.3**

NOTE: The T-45 does not have fuel dumping capability.

A. System status

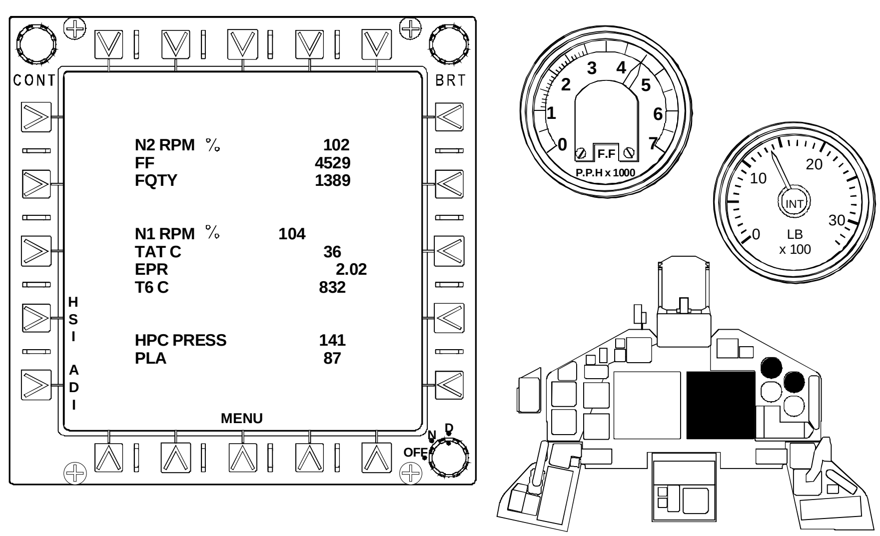


Figure 3: FUEL SYSTEM STATUS INDICATION

1. FUEL FLOW

   a. Fuel Flow indicator gauge

      (1) Location: right instrument panel, both cockpits

   b. ENGINE display page

      (1) Location: center instrument panel, either MFD, both cockpits

   c. Function: indicate rate of fuel to the engine combustion chamber in pounds per hour

      (1) Direct measure of volumetric fuel flow

      (2) Corrected for fuel density

2. FUEL QUANTITY

   a. Fuel Quantity indicator gauge

      (1) Location: right instrument panel, both cockpits

   b. Engine display page

      (1) Location: center instrument panel, either MFD both cockpits

   c. Function: indicate fuel remaining in 100 pound increments (uses capacitance type measuring system)

   d. No fuel quantity indication test system

Sg 3, fr 4
Fig 4: *Fuel System Caution Advisory*

B. Caution/advisory

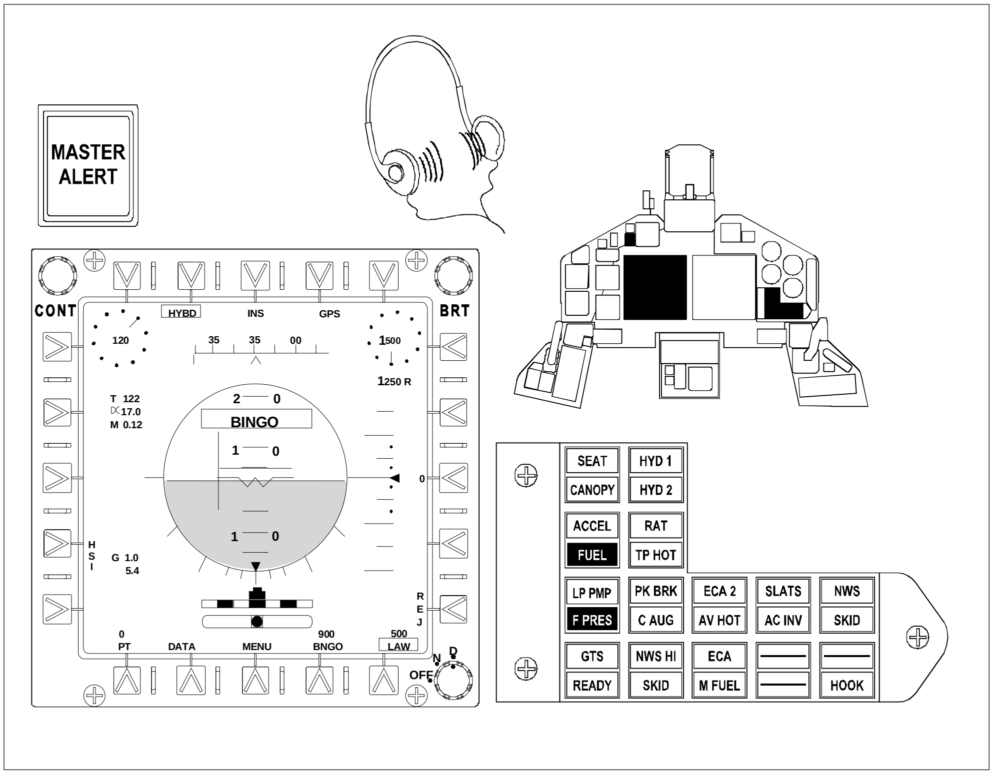


Figure 4: FUEL SYSTEM CAUTION ADVISORY

1. FUEL caution light

   a. Location: Caution advisory panel, both cockpits

   b. Function: indicates the available fuel remaining is less than 350-lb

   c. Operates off a different circuit than fuel quantity indicator

   NOTE: A 10-second CWS delay prevents erroneous/nuisance flickering caused by fuel sloshing. Once the 350-lb light illuminates with gear down, it stays on

2. F PRES caution light

   a. Location: Caution advisory panel, both cockpits

b. Function: Indicates loss of fuel tank pressurization (less than 2 psi above ambient) or insufficient pressure differential across the electrical fuel boost pumps

3. BINGO advisory

a. Location: Advisory window on all MFDs, both cockpits

b. Function: Advises pilot fuel level remaining is less than set

NOTE: BINGO fuel level is set by the pilot using option push-buttons on the DEP or the MFD

C. Controls

1. FUEL SHUTOFF T -handle

Sg 3, fr 5
Fig 5: *Fuel System Controls (Forward Cockpit Only)*

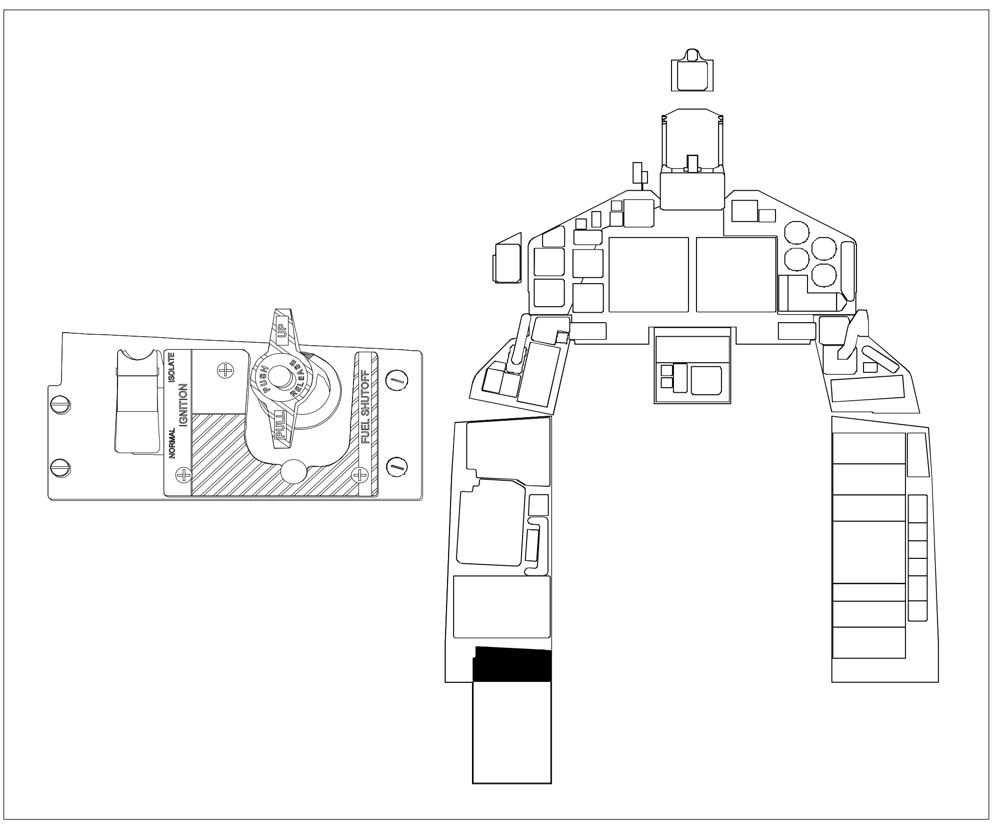


Figure 5: FUEL SYSTEM CONTROLS (FORWARD COCKPIT ONLY)

a. Location: aft panel of left console, fwd cocpit only

b. Function: opens and closes fuel shutoff valve, controlling fuel supply to engine (normal-open; during certain emergencies-closed)

(1) Down: permits fuel flow supply to the engine and GTS

(2) Pull up: isolated aircraft fuel system from the engine and GTs

PROGRESS CHECK

Question 1 — 1.4.7.2.1
How is fuel prevented from boiling at high altitudes?

ANSWER: The fuel tanks are pressurized to 6.0 psi above ambient.

Question 2 — 1.4.7.3
What indicates the loss of boost pump pressure?

ANSWER: The F PRES caution light illuminates on the Caution Advisory Panel

Question 3 — 1.4.7.3
What indicates that approximately 350 lb of fuel remain?

ANSWER: The FUEL caution light illuminates on the Caution Advisory Panel

IV. Aircraft interfaces **1.4.7.2**

A. Inputs

1. Electrical system

a. Indicators: 28 VDC essential services bus power source (boost pumps continue operating for 30 seconds after generator loss)

b. Boost pumps: 28 VDC essential services bus power source

(1) During starting (both ground and air starts), energized by 28 VDC essential services bus when the GTS start button is pressed and will drop off line 30 seconds after GTS shutdown unless generator comes on line

2. Engine air system: Output of fifth stage high pressure compressor filtered, regulated to 6.0 psi, and distributed to fuel tanks for pressurization

B. Outputs

1. Engine starting system

2. Engine fuel system

3. Centralized warning system (CWS): MASTER ALERT light flashes concurrently with caution advisory indications (FUEL, F PRES and BINGO)

4. Intercom system (ICS): caution tone sounds in headset concurrently with caution advisory indications (FUEL and F PRES)

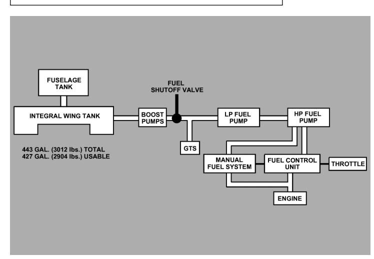
5. Airborne data recorder system (ADRS): monitors fuel quantity and fuel flow signals

Sg 5, fr 2
Lesson Organization

FUEL SYSTEM

* Major component identification
* Operational characteristics
* Controls, switches, and indicators
* **Aircraft interfaces**

Sg 5, fr 3
Simplified Fuel System Block Diagram



PROGRESS CHECK

Question 4 — 1.4.7.2
The 28 VDC Essential Services Bus supplies power to what fuel system component(s) during normal operation?

ANSWER: The boost pumps

Sg 10, fr 2
Review Menu

SUMMARY

This lesson has presented:

* Aircraft fuel system major component identification
* Operational characteristics
* Controls, switches, and indicators
* Aircraft interfaces

CONCLUSION

Knowing the fuel system operation and managing your fuel load are critical to completing your flight successfully.

LESSON GUIDE

COURSE/STAGE: TS, ADV & IUT / Engineering

LESSON TITLE: Fuel System Malfunctions

LESSON IDENTIFIER: T-45C TS, ADV & IUT ENG-08

LEARNING ENVIRONMENT: CAI

ALLOTTED LESSON TIME: .5 hr

TRAINING AIDS:

* Figures
  Fig 1: Caution Advisory Panel Indications
  Fig 2: Fuel Quantity Indicator
  Fig 3: Multi-Function Display (MFD)

STUDY RESOURCES:

* T-45C NATOPS Flight Manual, A1-T45AC-NFM-000
* T-45C NATOPS Pilot's Pocket Checklist, A1-T45AC-NFM-500

LESSON PREPARATION:

Read:
* Part I, Chapter 2.2, "Fuel System," T-45C NATOPS Flight Manual, A1-T45AC-NFM-000
* Part V dealing with fuel system malfunctions, T-45C NATOPS Flight Manual, A1-T45AC-NFM-000

Review:
* Lecture Guide for Eng-07, "Fuel System"

REINFORCEMENT: N/A

LESSON EXAMINATION:

Student is required to read fuel system and related malfunction paragraphs in the NATOPS Flight Manual, receive classroom instruction, and complete assigned CAI lesson(s). The student shall demonstrate knowledge by completing, from memory with 80% accuracy, true/false and multiple choice block examinations. The objectives in this lesson will be tested in either Engineering 29X or Engineering 30X.

LESSON OBJECTIVES

1.8.1.2.2.1
Identify indications of fuel tank pressurization failure

1.8.1.2.5.1
Identify indications of boost pump failure

1.8.1.2.1.1
Identify indications of fuel leaks

1.8.1.2.4.1
Identify indications of low fuel condition

MOTIVATION

Checking your fuel status is a routine job in the air. This lesson shows you how to identify fuel system malfunctions.

OVERVIEW

This lesson is designed to teach you to recognize four malfunctions related to the fuel system.

Later in the curriculum, you'll learn emergency procedures for each malfunction. In the simulator, you will put the procedures into action.

This lesson presents the following cockpit indications:

* Low fuel tank pressurization
* Boost pumps failure
* Fuel leaks
* Low fuel

REFRESHER

Recall the:

* Location and operation of aircraft fuel system components (fuel tanks, boost pumps, and negative-g compartment)

PRESENTATION

I. Fuel tank pressurization failure **1.8.1.2.2.1**

Fig 1: Caution Advisory Panel Indications

A. Indications

1. F PRES caution light illuminates

2. MASTER ALERT flashes

3. Caution tone sounds in headset

B. Verifications

1. Above 25,000 ft, fuel vaporization may cause

a. Fuel venting (confirm by checking with wingman, if available)

b. Excessive fuel loss

2. Below 25,000 ft: no verification

CAUTION: In the absence of any verification, always assume that any warning or caution light accurately indicates a malfunction

C. Effects on flight safety

1. Possible fuel loss

2. Possible adverse effects on engine performance at high power settings

3. Fuel transfer affected by erratic maneuvers

II. Boost pumps failure **1.8.1.2.5.1**

Fig 1: Caution Advisory Panel Indications

A. Indications

1. F PRES caution light illuminates

2. MASTER ALERT flashes

3. Caution tone sounds in headset

B. Verifications

1. No secondary indications

2. No verification possible

NOTE: Assume that a malfunction has occurred whenever the primary indications occur.

C. Effects on flight safety

1. Fuel to engine maintained by LP pump suction via boost pump bypass valve

2. Negative-g maneuvers may cause the engine to flame out

III. Fuel leaks **1.8.1.2.1.1**

Fig 2: Fuel Quantity Indicator

A. Indications

1. Fuel quantity indicator reads significantly lower than planned fuel consumption

2. Wingman or other aircraft notices vapor trail

B. Verifications

1. No test for fuel gauge accuracy

2. If gauge indicates leak, get visual verification from cockpit or other aircraft

NOTE: Lack of visual verification does not nullify the possibility of a leak. A leak could be more serious if it's not visible because it might be at the engine.

C. Effects on flight safety

1. Rate of loss significant: immediate emergency if fuel loss is excessive

2. If leak is near engine, be aware of fire hazard

3. Possible flameout

IV. Low fuel **1.8.1.2.4.1**

A. Indications

1. FUEL caution light illuminates and stays lit

2. MASTER ALERT flashes

3. Caution tone sounds in headset

B. Verification

1. Fuel quantity indicator reads approximately 350 lb or below

NOTE: If the fuel quantity indicator reads above 350 lb, assume that the FUEL light is valid. If gauge reads less than 350 lb but the FUEL light is not illuminated, assume the gauge is correct. Always assume the lower of the two is correct.

C. Effect on flight safety: possible flameout

NOTE: The most conservative altitude and speeds can be determined by using NATOPS maximum range/endurance charts.

D. Bingo fuel

1. BNGO setting readout is located on the MFD (ADI display) above the BNGO option, on power-up default 900 with adjustable setting from 0 to 3000 lbs in 100 lb. increments

a. The setting is entered using the (increase/decrease) on the ADI display or the Data Entry Panel (DEP) using numeric keypad

2. BINGO advisory and CAUTION

a. A BINGO advisory is displayed on the ADI display along with flashing of the BNGO numeric and legend when aircraft fuel quantity is less than or equal to the set value

b. BNGO flashing will continue after the advisory is rejected as a reminder until the setting is reset to below the fuel quantity level

c. A caution is displayed on the HUD

Fig 1: *Caution Advisory Panel Indications*

Fig 3: *Multi-Function Display (MFD)*

SUMMARY

In this lesson you have learned about four possible malfunctions related to the fuel system:

* Fuel tank pressurization failure
* Boost pumps failure
* Fuel leaks
* Low fuel

CONCLUSION

Being able to recognize aircraft system malfunctions quickly is critical to making safe and logical decisions in an emergency.

The conditions described in this lesson might occur in conjunction with each other or with some other malfunction related to another aircraft system and often during high workload situations. Your safety depends on your ability to detect and evaluate a malfunction correctly in relationship to another and to act accordingly.

If this lesson has raised any questions for you, be certain to contact your instructor.

FIGURES

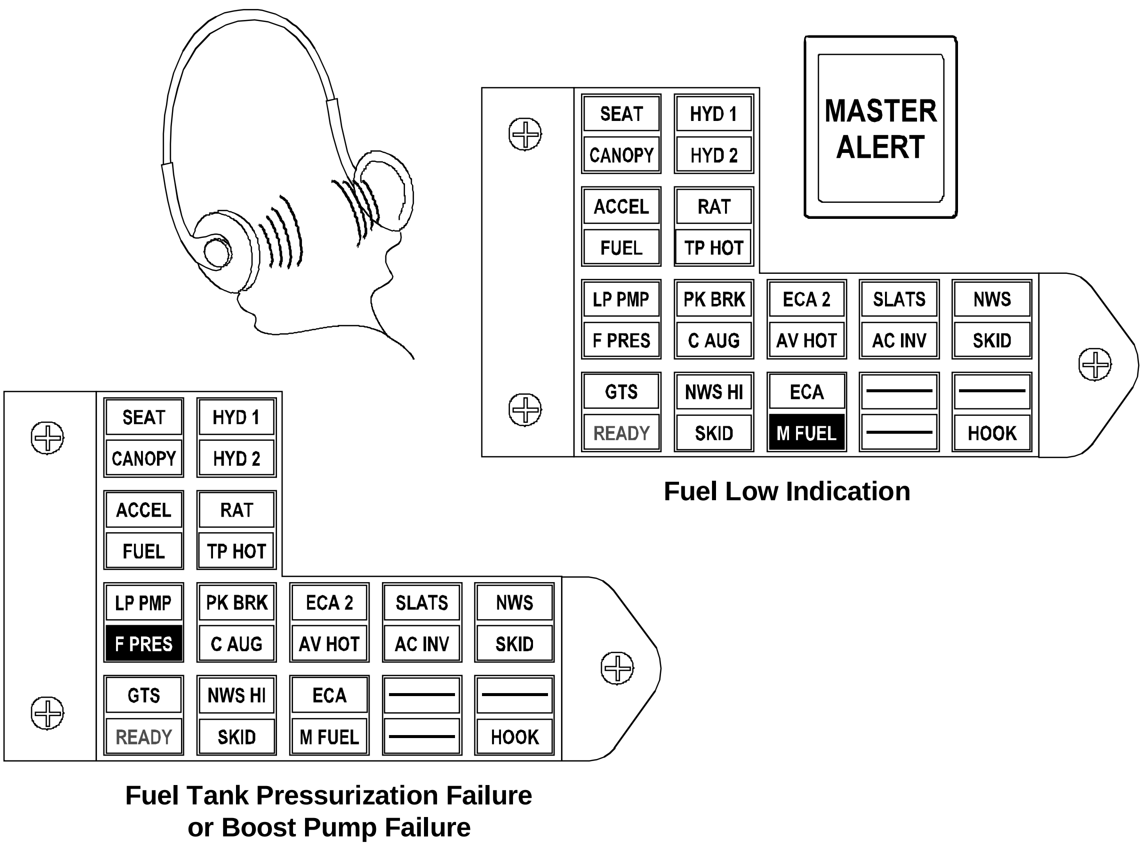


Figure 1: CAUTION ADVISORY PANEL INDICATIONS

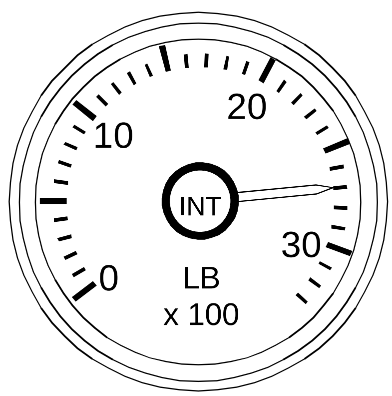


Figure 2: FUEL QUANTITY INDICATOR

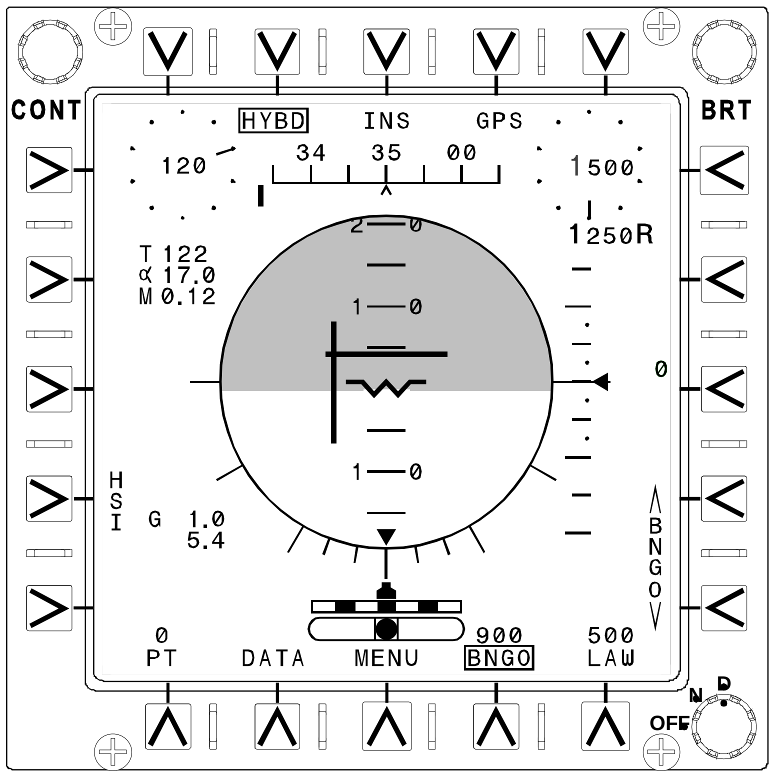


Figure 3: MULTI-FUNCTION DISPLAY (MFD)

LECTURE GUIDE

COURSE/STAGE: TS, ADV & IUT Engineering

LESSON TITLE: Hydraulic System

LESSON IDENTIFIER: T-45C TS, ADV & IUT ENG-09

LEARNING ENVIRONMENT: Classroom

ALLOTTED LESSON TIME: 1.0 hr

TRAINING AIDS:

* Wall Charts
  Cutaway View T-45C
  T-45C Cockpit
* Figures
  Fig 1: Hydraulic System Pressure Gauges/Reset Button
  Fig 2: Warning and Caution Advisory Light Panels
  Fig 3: Hydraulic System Block Diagram
  Fig 4: Wheel Brake/Emergency Flap Accumulator Pressure Gauge
  Fig 5: HYD 1 FC Accumulator Pressure Gauge
  Fig 6: HYD 1 Filter Indicator
  Fig 7: HYD 1 Reservoir Indicator
  Fig 8: HYD 2 FC Accumulator Pressure Gauge
  Fig 9: Left Side External Locator

STUDY RESOURCES:

* <u>T-45C NATOPS Flight Manual</u>, A1-T45AC-NFM-000

(9-98) CHANGE 4

LESSON PREPARATION:

Read:

Part I, Chapter 2.4, "Hydraulic System," T-45C NATOPS Flight Manual, A1-T45AC-NFM-000

REINFORCEMENT: N/A

EXAMINATION:

Student is required to read hydraulic system and related malfunction paragraphs in the NATOPS Flight Manual, receive classroom instruction, and complete assigned CAI lesson(s). The student shall demonstrate knowledge of the T-45C hydraulic system by completing, from memory with 80% accuracy, true/false and multiple choice block examinations. The objectives in this lesson will be tested in either Engineering 29X or Engineering 30X.

LESSON OBJECTIVES

1.4.8.3.1
Recall major components of the HYD 1 system

1.4.8.2.1
Recall operating characteristics of the HYD 1 system

1.4.8.3
Recall function, purpose, and location of HYD 1 system controls, switches, and indicators

1.4.8.3.2
Recall major components of the HYD 2 system

1.4.8.2.2
Recall operating characteristics of the HYD 2 system

1.4.8.5
Recall function, purpose, and location of HYD 2 system controls, switches, and indicators

1.4.8.2
Recall interfaces between the hydraulic system and other a/c systems

MOTIVATION

Many components of the T-45C are hydraulically operated. The ailerons and stabilator are totally dependent on hydraulic power. Your knowledge of the hydraulic system is critical.

OVERVIEW

For the T-45C, you will describe the purpose and functional characteristics of--and location of controls and indicators for--the hydraulic system as well as the interfaces between the hydraulic and other T-45C systems.

Engineering 09 will cover the following:

* T-45C hydraulic system overview
* Hydraulic system no. 1 (HYD 1)
* Hydraulic system no. 2 (HYD 2)
* Emergency hydraulic system
* Aircraft interfaces

REFRESHER

This lesson builds on information presented previously. In particular, remember that the:

* T-45C engine accessory gearbox drives the two hydraulic system pumps
* T-45C hydraulic system supplies hydraulic pressure to the ailerons, arresting hook, flaps, slats, landing gear, launch bar, NWS, speed brakes, stabilator, and wheel brakes (including anti-skid)
* Emergency Hydraulic System provides backup emergency hydraulic pressure to the flight controls only

PRESENTATION

I. T-45C hydraulic system overview

A. T-45C has two independent hydraulic systems: HYD 1 and HYD 2. Each system contains a reservoir and is pressurized by an engine-driven pump (EDP).

1. HYD 1 provides hydraulic pressure to power the flight controls (ailerons and stabilator) and the general services.

2. HYD 2 provides hydraulic pressure to power only the flight controls.

B. A deployable ram air turbine (RAT) provides emergency hydraulic system pressure which, in case of a failure of HYD 2 EDP, should provide pressure to the flight controls. The emergency system is integral to the HYD 2 system.

C. Hydraulic system controls and indicators

1. Cockpit controls and indicators

a. HYD 1, HYD 2, and BRAKE pressure gauges

b. HYD 2 RESET button

c. Warning and caution advisory panels

(1) HYD FAIL warning light

(2) HYD 1 and HYD 2 and RAT caution lights

2. Aircraft exterior indicators

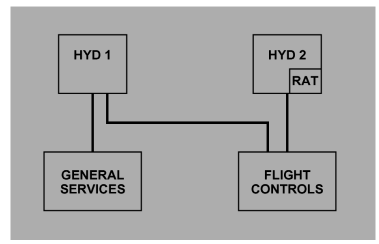
a. Accumulator pressure gauges: HYD 1 FC; HYD 2 FC; wheelbrake/emergency flap

b. HYD 1 and HYD 2 reservoir quantity indicators

Sg 1, fr 2
Lesson Organization

HYDRAULIC SYSTEM
* **T-45C hydraulic system overview**
* Hydraulic system no. 1 (HYD 1)
* Hydraulic system no. 2 (HYD 2)
* Emergency hydraulic system
* Aircraft interfaces

Sg 1, fr 3, p 1
Simplified Hydraulic System Block Diagram (3 overlays)



Overlay 1
HYD 1 System

Overlay 2
HYD 2 System

Overlay 3
RAT

Wall Chart: *Cutaway View T-45C*

Wall Chart: *T-45C Cockpit*

Sg 1, fr 5
Fig 1: *Hydraulic System Pressure Gauges/Reset Button*

Sg 1, fr 7
Fig 2: *Warning and Caution Advisory Light Panels*

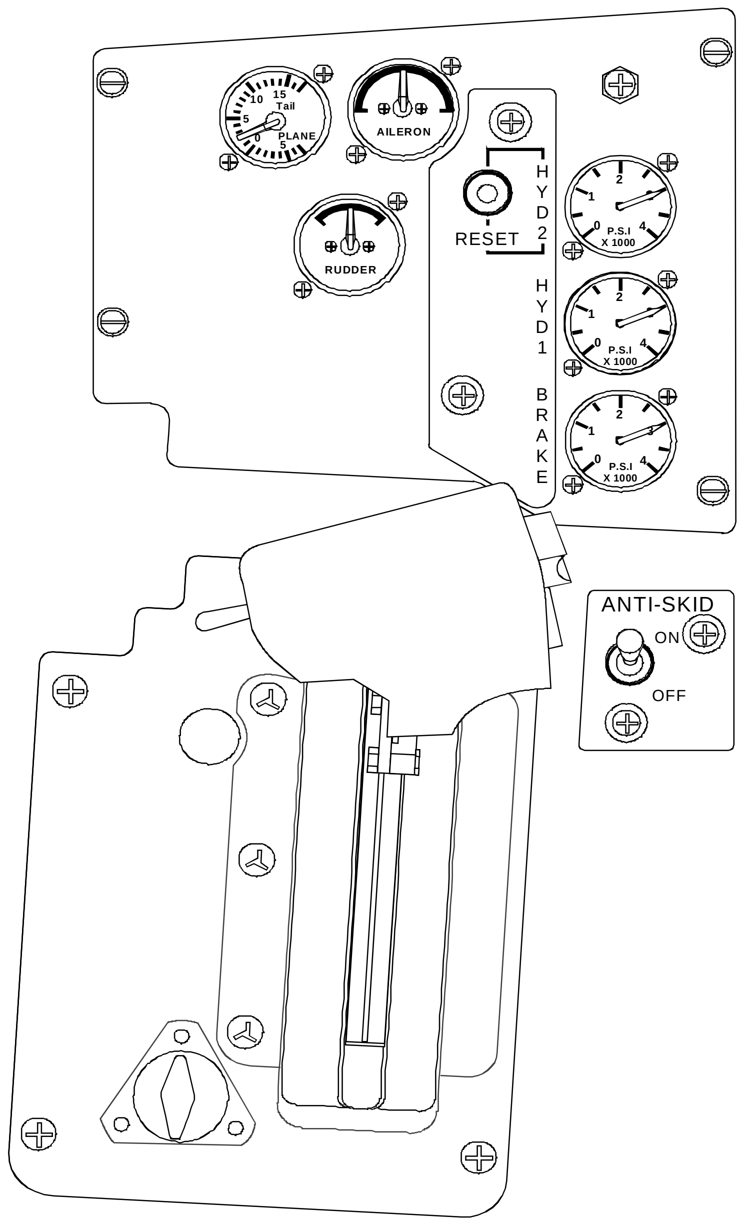


Figure 1: HYDRAULIC SYSTEM PRESSURE GAUGES/RESET BUTTON

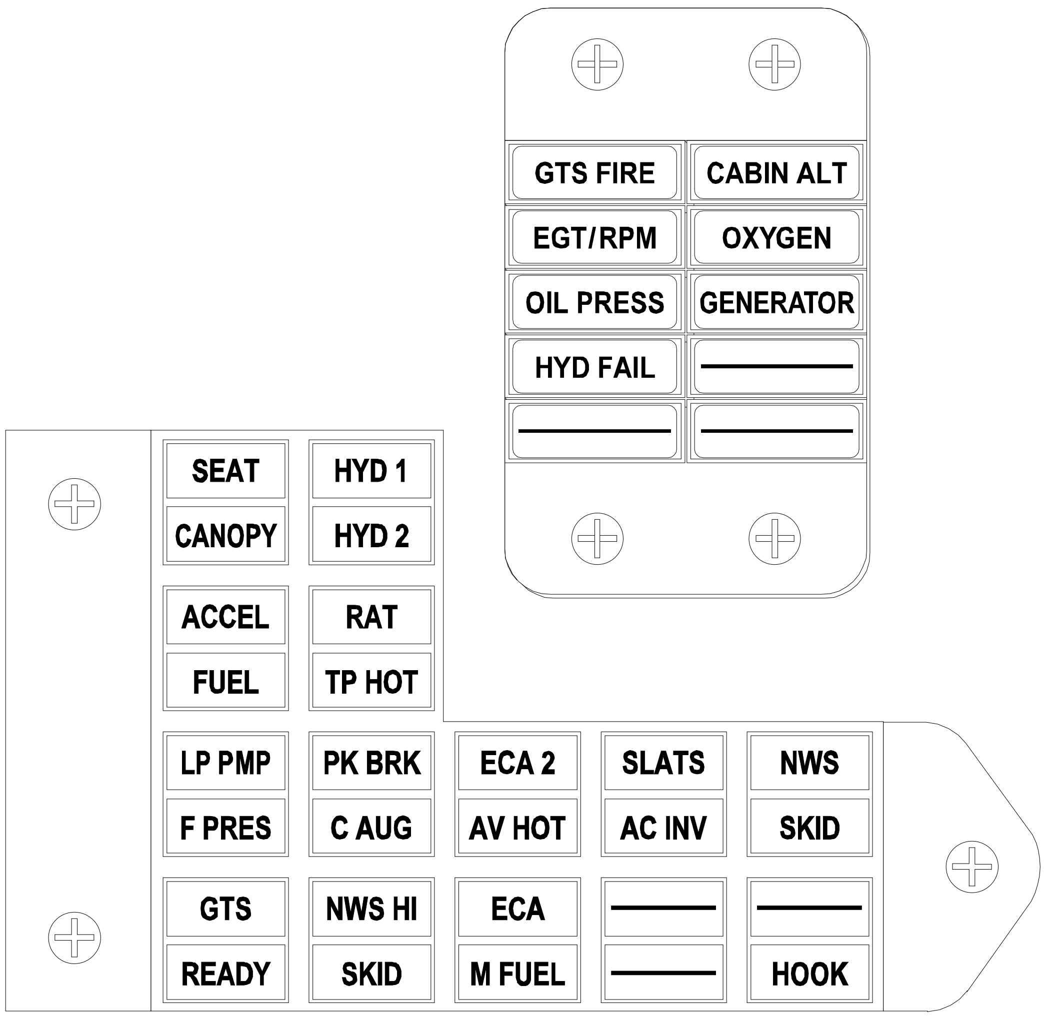


Figure 2: WARNING AND CAUTION ADVISORY LIGHT PANELS

c. HYD 1 and HYD 2 filter indicators

NOTE: Each of these systems will be discussed in detail

LESSON NOTES

Use the T-45C cockpit and aircraft cutaway view wall charts to identify controls, indicators, and components during this lesson. Emphasize component functional descriptions.

Sg 2, fr 2
Lesson Organization

HYDRAULIC SYSTEM

* T-45C hydraulic system overview
* **Hydraulic system no. 1 (HYD 1)**
* Hydraulic system no. 2 (HYD 2)
* Emergency hydraulic system
* Aircraft interfaces

II. Hydraulic system no. 1 (HYD 1) **1.4.8.3.1**

A. Description:

The HYD 1 reservoir supplies fluid to the HYD 1 engine-driven pump (EDP) that, in turn, produces hydraulic pressure to power the flight controls and general services.

NOTE: Control of the rudder is strictly mechanical.

Sg 2, fr 3, p 1
Fig. 3: *Hydraulic System Block Diagram (7 Overlays)*

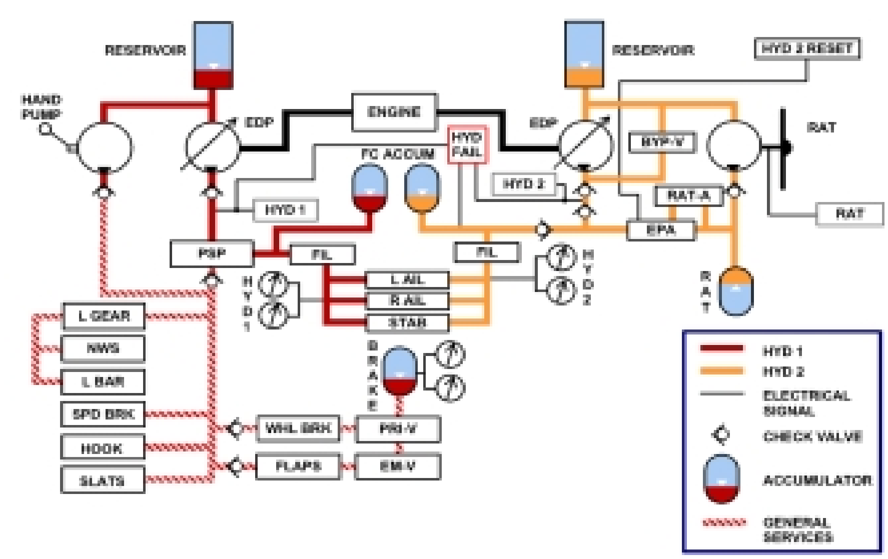


Figure 3: HYDRAULIC SYSTEM BLOCK DIAGRAM

B. HYD 1 components

1. Reservoir

Overlay 1
HYD 1 Reservoir

a. Location: ram air turbine (RAT) bay, top side of aircraft, forward of the tail section

(1) Stores hydraulic fluid for HYD 1 operation

(2) Provides fluid under nitrogen preload pressure to HYD 1 to prevent EDP cavitation

(3) Provides fluid pressure to component seals during nonoperating periods to minimize leaks

b. Physical

(1) Consists of a cylinder with a free-floating piston that separates fluid from nitrogen

(2) Pressurized by nitrogen during ground maintenance

(3) Fluid quantity depends both on quantity remaining in accumulators and the hydraulic fluid temperature

(4) Has external quantity gauge

2. Engine-driven pump (EDP)

Overlay 2
HYD 1 EDP

a. Location: aft right side of engine accessory gearbox

b. Description

(1) Produces hydraulic pressure for HYD 1 system

(2) Output volume varies in response to demand

c. Physical

(1) Mounted on and driven by engine accessory gearbox

(2) Variable displacement pump

(3) Constant output pressure: 3000 psi at 9.6 gallons per minute

__Overlay 3__
HYD 2 FC Accumulator

3. Flight control (FC) accumulator

a. Location: aft of right intake

b. Description

(1) Stores power for ailerons and stabilator during periods of high demand

(2) Dampens pressure fluctuations

c. Physical

(1) Consists of a cylinder with a free-floating piston that separates fluid from nitrogen

(2) Pressurized with nitrogen (1100 $\pm$ 50 psi)

__Overlay 4__
Wheel Brake/ Emergency Flap Accumulator

4. Wheel brake/emergency flap accumulator

a. Location: right main landing gear wheel bay

b. Description

(1) Stores power for emergency use of wheel brakes in event of HYD 1 failure

(2) Stores power for emergency deployment of full flaps in event of HYD 1 failure (no retraction)

(3) Supplies enough pressure for at least 10 full wheel brake applications following emergency flap extension

(4) Dampens pressure fluctuations

c. Physical

(1) Consists of a cylinder with a free-floating piston that separates fluid from nitrogen

(2) Pressurized with nitrogen (1300 ± 50 psi)

5. Power supply package

Overlay 5
Power Supply Package

a. Flight control

(1) Location: aft right fuselage, right behind wing

(2) Description

(a) A priority valve isolates general services and redirects HYD 1 pressure to flight controls when HYD 1 pressure drops below 1500 psi

(b) When HYD 1 pressure above 1600 psi, a priority valve redirects pressure to the general services

(c) Provides system pressure relief caused by system heat

(3) Physical: Multi-valve package consisting of:

(a) Priority valve

(b) A pressure relief valve

(c) Two check valves

Overlay 6
Wheel Brake/ Emergency Flap Priority Valve

b. Wheel brake/emergency flap valve

(1) Location: bottom, center fuselage (between intakes)

(2) Description: with HYD 1 system loss, priority valve disables emergency flap operation from the wheel brake/emergency flap accumulator at 2200 psi

(3) Physical: part of multi-valve package consisting of a priority valve, a thermal relief valve, and a standby flap system emergency valve

Overlay 7
Hand Pump

Sg 2, fr 6
Hand Pump (Video)

6. Hand pump

a. Location: right intake, door labeled HYD HAND PUMP/ GROUND LOCK PINS

NOTE: The hand pump is not accessible to the aircrew from the cockpit.

b. Description:

(1) Functional: hand pump supplies up to 2800 psi to recharge wheel brake/ emergency flap accumulator without starting engine or applying external hydraulic pressure (wheel brakes must be operative prior to towing aircraft)

(2) Physical

(a) Fixed displacement pump

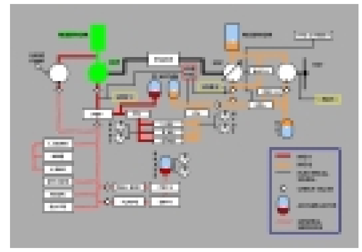
(b) Detachable handle

LESSON NOTES

The hand pump is operated with a breaker bar with a 1/2-inch drive, 3-inch extension through an access that is labeled HYD HAND PUMP.

C. HYD 1 operational characteristics **1.4.8.2.1**

Sg 2, fr 7, p 1
Hydraulic System Block Diagram (5 Overlays)



1. Input power: supplied by EDP

   a. EDP receives hydraulic fluid from HYD 1 reservoir under low pressure

   b. EDP produces output of 3000 psi

   c. Pressure switch senses output pressure and provides HYD 1 failure signal to centralized warning system (CWS) to illuminate HYD 1 caution light when pressure drops below 1660 ± 110 psi (after AFC-244), or below 600 ± 50 psi (before AFC-244). When HYD 1 pressure rises above 2000 psi (after AFC-244), or above 725 ± 50 psi (before AFC-244), HYD 1 caution light goes out

Overlay 1
HYD 1
Caution Light

2. Output distribution: controlled by FC priority valve

Overlay 2
Power Supply Package (PSP)

Overlay 3
FC Priority Valve (PSP) Output Distribution

   a. Output of EDP is applied to power supply package

   b. FC priority valve normally supplies hydraulic pressure to both FC services and general services distribution

   c. Flight control services

Overlay 4
FC Services

      (1) Left and right aileron power control units (PCUs): tandem hydraulic cylinders, one side supplied by HYD 1 and other by HYD 2 (HYD 1 supplies forward side of aileron PCUs; HYD 2 supplies aft side)

      (2) Stabilator PCU (also a tandem PCU)

      (3) System redundant with HYD 2

Overlay 5
General Services

   d. General services

(1) Landing gear (hydraulic pressure used for both extension and retraction)

(2) Nose wheel steering (hydraulic pressure through the down side of the normal landing gear system)

(3) Launch bar (hydraulic pressure used for extension only; retraction is mechanical by spring force)

(4) Speed brake (hydraulic pressure used for both extension and retraction)

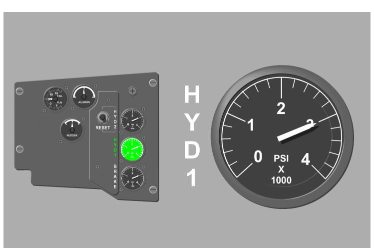
(5) Arresting hook (hydraulic pressure used for retraction only; extension is by gravity free-fall, with pneumatic snubber pressure assist)

(6) Flaps and slats (hydraulic pressure used for both extension and retraction)

Sg 2, fr 10, p 1
Hydraulic System Pressure Gauges/Reset Button (1 Overlay)

(7) Wheel brakes and anti-skid (hydraulic pressure used for both operations)

D. HYD 1 controls, switches, and indicators **1.4.8.3**



Overlay 1
BRAKE Pressure Gauge

1. Left console, both cockpits

a. HYD 1 pressure gauge

(1) Indicates output of HYD 1 system pressure

(2) Calibrated from 0 to 4000 psi in 200 psi increments and labeled every 1000 psi

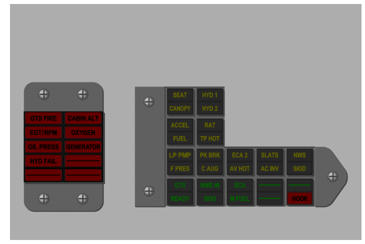
b. BRAKE pressure gauge

(1) Indicates nitrogen pressure in wheel brake/ emergency flap accumulator (not system hydraulic pressure)

(2) Calibrated from 0 to 4000 psi in 200 psi increments and labeled every 1000 psi

2. Warning and caution advisory panels, both cockpits: HYD 1 caution light alerts aircrew of HYD 1 failure. Illuminates the HYD 1 caution light when pressure drops below 1660 ± 110 psi (after AFC-244), or below 600 ± 50 psi (before AFC-244). When HYD 1 pressure rises above 2000 psi (after AFC-244), or above 725 ± 50 psi (before AFC-244), the HYD 1 caution light goes out

Sg 2, fr 11
Warning and Caution or Advisory Light Panel



3. Aircraft exterior

   a. Right main wheelwell

      (1) Wheel brake/emergency flap accumulator pressure gauge

Sg 2, fr 14
***Fig 4:** Wheel Brake/ Emergency Flap Accumulator Pressure Gauge*

         (a) Indicates pressure in wheel brake/ emergency flap accumulator (same measurement as cockpit BRAKE pressure gauge)

         (b) Calibrated from 0 to 4000 psi in 100 psi increments and labeled every 1000 psi

         (c) When hydraulic fluid supply depleted from accumulator, gauge displays nitrogen pressure only

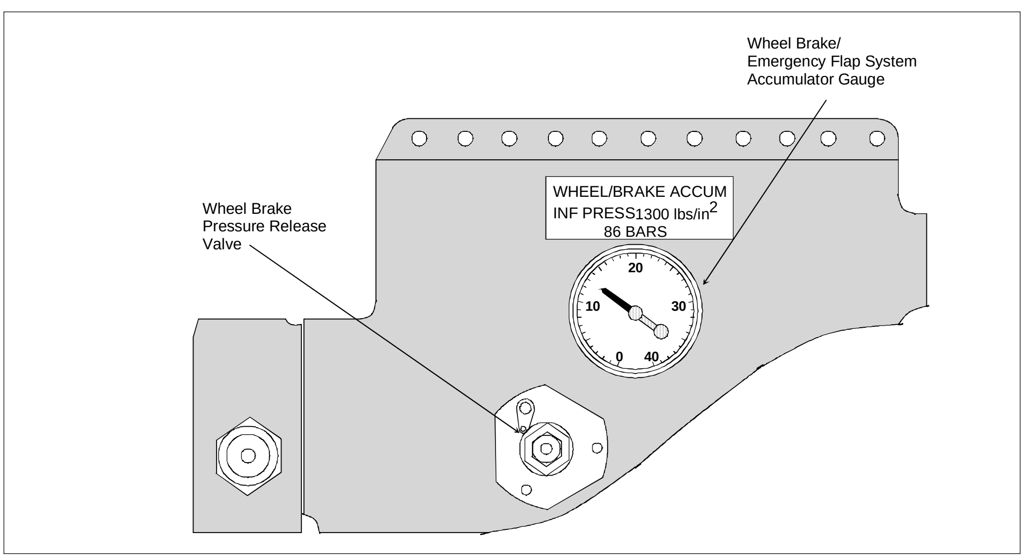


Figure 4: WHEEL BRAKE/EMERGENCY FLAP ACCUMULATOR PRESSURE GAUGE

Sg 2, fr 15
Fig 5: *HYD 1 FC Accumulator Pressure Gauge*

(d) 1300 psi or greater

(2) HYD 1 FC accumulator pressure gauge

(a) Indicates pressure in HYD 1 FC accumulator (accumulator pressure, as opposed to system output pressure read from HYD 1 pressure gauge in cockpit)

(b) Calibrated from 0 to 4000 psi in 100 psi increments and labeled every 1000 psi

(c) When hydraulic fluid supply is depleted from accumulator, gauge displays nitrogen pressure only

(d) Serviced to 1100 ± 50 psi

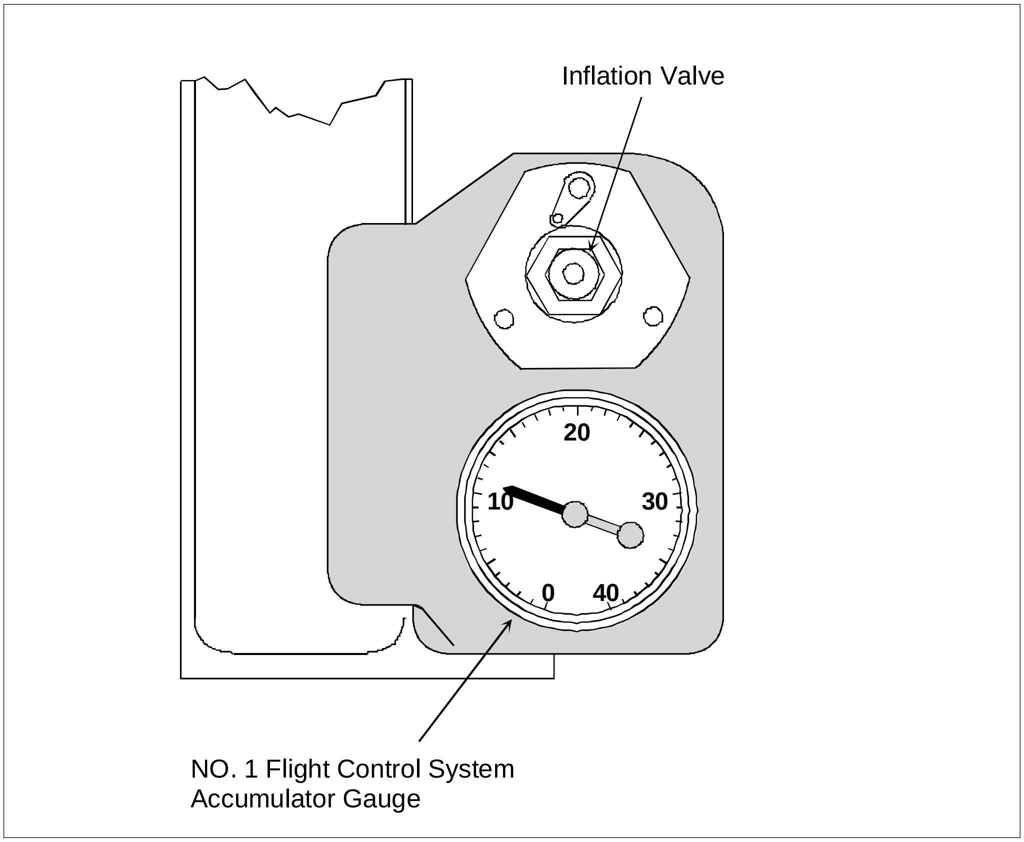


Figure 5: HYD 1 FC ACCUMULATOR PRESSURE GAUGE

Sg 2, fr 16
Fig 6: *HYD 1 Filter Indicator*

b. Aft fuselage (right side)

(1) HYD 1 filter indicators

(a) Two indicators, forward one for pressure line and aft one for return line

(b) Service required when red band visible

NOTE: The indicator protrudes (pops out), exposing the red band, when the filter is clogged and the internal bypass valve opens.

NOTE: Indicators occasionally pop out due to pressure fluctuations or g forces encountered during hard landings.

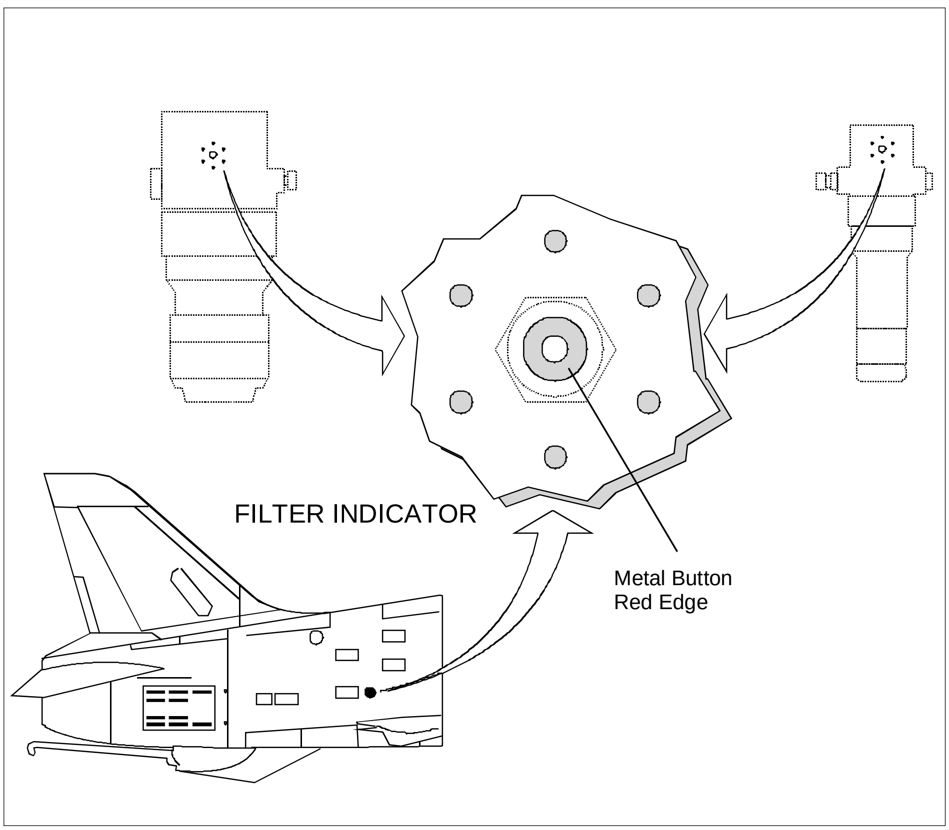


Figure 6: HYD 1 FILTER INDICATOR

Sg 2, fr 17
Fig 7: *HYD 1 Reservoir Indicator*

(2) HYD 1 reservoir indicator

(a) Indicates quantity of HYD 1 reservoir

(b) Quantity will vary according to temperature of fluid and pressure in system

(c) Calibrated 0-340 cubic inches in 10 cubic-inch increments and labeled every 100 cubic inches

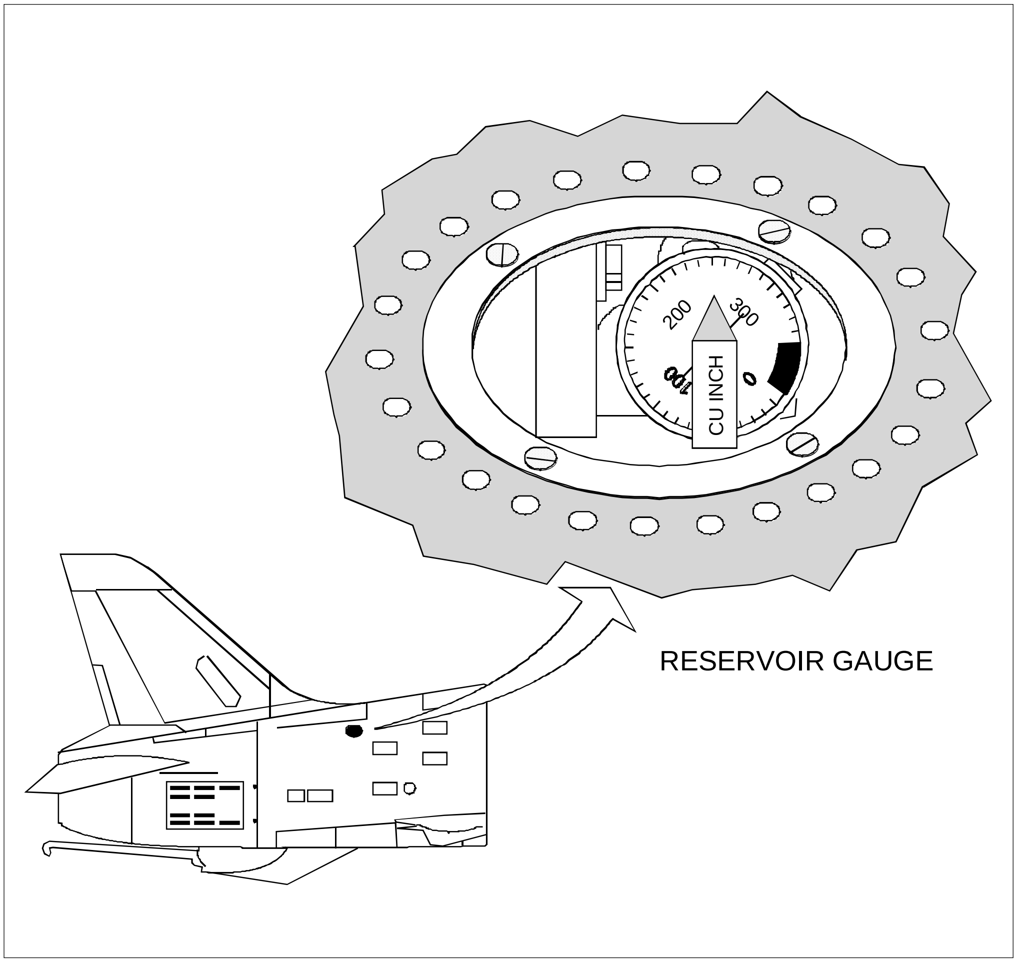
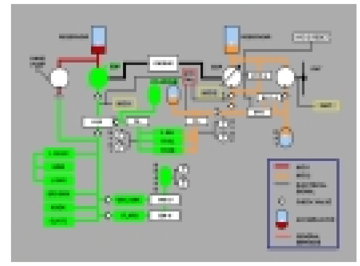


Figure 7: HYD 1 RESERVOIR INDICATOR

E. HYD 1 malfunctions

Sg 2, fr 18, p 1
Hydraulic System Block Diagram (3 overlays)



1. HYD 1 pressure falls below 1500 psi

   a. If HYD 1 pressure drops below 1500 psi for any reason (pump failure, excessive demand, engine flameout, or leak in system), FC priority valve shuts off general services distribution

      (1) No backup for some general services, i.e., slats and speed brakes

      NOTE: Speed brakes will blow back by force of airstream at speeds over 380 KIAS

Overlay 1
Wheel Brake/ Emergency Flap Accumulator

      (2) General services with independent backup

         (a) Landing gear: gravity free-fall backup for extension only

         (b) Flaps: one full flap extension backup supplied by wheel brake/emergency flap accumulator

         (c) Wheel brakes: 10 full applications after emergency flap extension supplied by wheel brake/emergency flap accumulator

   b. If HYD 1 pressure (≥ 1600 psi) is regained (e.g., after engine restart or reduced demand), FC priority automatically reselects general services

2. HYD 1 EDP pressure falls below 1660 ± 110 psi or 600 ± 50 psi

Overlay 2
HYD 1 Caution Light

   a. MASTER ALERT light flashes

   b. HYD 1 caution light illuminates and caution tone sounds

   c. Hydraulic pressure is provided to flight control services as long as HYD 2 (or RAT) remains operational (to other side of tandem actuators)

Overlay 3
Check Valves

3. Leak in HYD 1

    a. Check valves limit loss of fluid if leak is confined to an individual component (e.g., leaking launch bar actuator)

    b. Indications

        (1) Visual confirmation

        (2) When pressure drops below 1500 psi, general services isolated from system

        (3) When pressure drops below 1660 ± 110 psi or 600 ± 50 psi, HYD 1 caution light illuminates

F. HYD 1 operational characteristics summary:

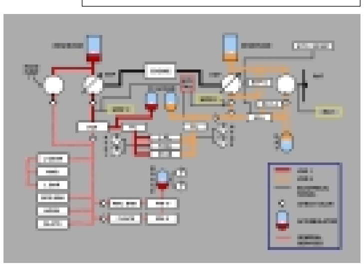
HYD 1 is an independent hydraulic system used to power the flight controls and general services. If HYD 1 fails, some general services will be lost while others will operate on emergency backup systems only.

Sg 3, fr 2
Lesson Organization

HYDRAULIC SYSTEM
* T-45C hydraulic system overview
* Hydraulic system no. 1 (HYD 1)
* **Hydraulic system no. 2 (HYD 2)**
* Emergency hydraulic system
* Aircraft interfaces

III. Hydraulic system no. 2 (HYD 2) **1.4.8.3.2**

Sg 3, fr 3, p 1
Hydraulic System Block Diagram (5 Overlays)



A. Description

The HYD 2 reservoir supplies fluid to the HYD 2 engine-driven pump (EDP) that, in turn, produces hydraulic pressure to power the flight controls.

B. HYD 2 components

1. Reservoir

Overlay 1
HYD 2 Reservoir

    a. Location: RAT bay, topside of aircraft, forward of the tail section

        (1) Stores hydraulic fluid for HYD 2 operation

        (2) Provides fluid under nitrogen preload pressure to HYD 2 to prevent EDP cavitation

(3) Provides fluid pressure to component seals during nonoperating periods to minimize leaks

b. Physical

(1) Similar to HYD 1 reservoir, except smaller, less load, less capacity. Consists of a cylinder with a free-floating piston that separates fluid from nitrogen

(2) Pressurized by nitrogen during ground maintenance

(3) Fluid quantity depends both on quantity remaining in the accumulators and the hydraulic fluid temperature

2. Engine-driven pump (EDP)

Overlay 2
HYD 2 EDP

a. Location: forward left side of engine accessory gearbox

b. Description

(1) Produces hydraulic pressure for HYD 2 system

(2) Output volume varies in response to demand

c. Physical

(1) Mounted on and driven by engine accessory gearbox

(2) Variable displacement pump

(3) Constant output pressure: 3000 psi at 6 gpm flow due to smaller load

3. FC accumulator

Overlay 3
HYD 2 FC Accumulator

a. Location: left intake above wing

b. Description

(1) Stores power for aileron and stabilator during periods of high demand

(2) Dampens pressure fluctuations

c. Physical

(1) Consists of a cylinder with a free-floating piston that separates fluid from nitrogen

(2) Pressurized with nitrogen (1100 $\pm$ 50 psi)

Overlay 4
Emergency Package Assembly

4. Emergency package assembly

a. Location: left upper fuselage behind wing

b. Description

(1) Functional

(a) Allows HYD 2 to charge RAT accumulator during normal operation

(b) Automatically deploys RAT and directs emergency hydraulic pressure to flight control services when HYD 2 pressure drops below 1500 psi

(c) Isolates sections of the HYD 2 system from the emergency hydraulic system when the RAT is deployed

(d) Allows resetting of the HYD 2 system via solenoid valve with HYD 2 pressure above 1800 psi

NOTE: The HYD 2 reset button must be pressed to regain HYD 2 EDP pressure and stow the RAT.

(2) Physical

(a) Thermal relief valve

(b) Spool valve

(c) Solenoid valve (reset)

(d) Restrictor

NOTE: This group of valves combines to determine change over pressure between the HYD 2 EDP and emergency hydraulic system.

5. EDP bypass valve

Overlay 5
EDP Bypass Valve

a. Location: bottom, left aft fuselage

b. Description

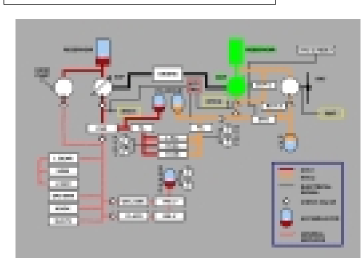
(1) Reduces load on engine during start by bypassing output of EDP to return side of system

(2) Bypass in effect when engine below 42% rpm, e.g., start, flameout

(3) Can be reset when engine is above 45% rpm by pressing HYD 2 RESET button

C. HYD 2 operational characteristics **1.4.8.2.2**

Sg 3, fr 5, p 1
Hydraulic System
Block Diagram
(3 Overlays)



1. Input power: supplied by EDP

a. EDP receives hydraulic fluid from HYD 2 system reservoir

b. HYD 2 EDP also produces 3000 psi but at reduced (6 gpm) flow because of smaller load

c. Bypass valve controls output of EDP

Overlay 1
Bypass Valve/Reset Button

Overlay 2
Bypass Valve Output Distribution

Overlay 3
HYD 2 Pressure Lines

(1) Engine rpm controls the bypass valve through the airborne data recorder (ADR), and HYD 2 RESET button

(2) On engine start, bypass valve opens to send HYD 2 EDP output to return (reduces load on ATS during engine start)

(3) May be reset (bypass valve closed) by pressing HYD 2 RESET button once engine rpm has reached 45%

(4) If engine rpm drops below 42% (flameout), bypass valve opens

(a) Valve opens to reduce load on engine during start (airstart)

(b) When engine rpm rises above 45%, bypass valve may be closed by pressing the HYD 2 RESET button

NOTE: When airborne, the RAT will begin supplying Emergency Hydraulic System when HYD 2 EDP pressure drops below 1500 psi. If RAT deploys as a result of a decrease in HYD 2 pressure caused by excessive demand, HYD 2 reset should be accomplished to stow the RAT.

2. Output distribution

a. Supplies flight controls

(1) To trailing edge side of aileron PCUs

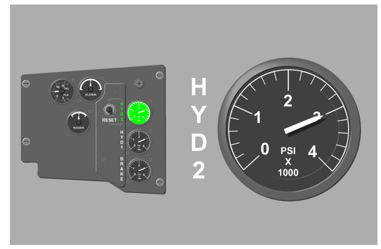
(2) To stabilator PCU

b. Charges HYD 2 system FC accumulator

c. Supplies emergency package assembly

D. HYD 2 controls, switches, and indicators **1.4.8.5**

Sg 3, fr 7, p 1
Hydraulic System Pressure Gauges/ Reset Button (1 Overlays)



1. Left console, both cockpits

   a. HYD 2 pressure gauge

      (1) Indicates HYD 2 system or Emergency Hydraulic System pressure

      (2) Calibrated from 0 to 4000 psi in 200 psi increments and labeled every 1000 psi

   b. HYD 2 RESET button

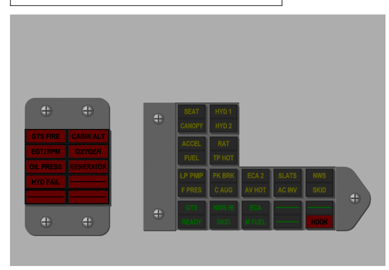
Overlay 1
HYD 2 RESET Button

      (1) Resets and stows RAT if HYD 2 EDP pressure above 1800 psi

      (2) Resets HYD 2 EDP bypass valve when engine rpm above 45%

      NOTE: Electrical power is supplied by the 28 VDC essential services bus.

Sg 3, fr 8
Warning and Caution Advisory Light Panels (2 Overlays)



2. Warning and caution advisory light panels, both cockpits

   a. HYD 2 caution light alerts aircrew to possible HYD 2 EDP failure: illuminates when HYD 2 EDP pressure drops below 1660 $\pm$ 110 psi. It will also illuminate with functional HYD 2 EDP in cases where excessive demand drops HYD 2 pressure below 1660 psi. It extinguishes when HYD 2 EDP pressure is above 2000 psi

Overlay 1
HYD 2 Caution Light

   NOTE: As long as the HYD 2 pressure gauge is cycling between 2500 and 3000 psi, the RAT is functioning and is producing sufficient hydraulic pressure to power the flight controls.

   b. RAT caution light indicates that the RAT is extended

Overlay 2
RAT Caution Light

Sg 3, fr 11
Fig 8: *HYD 2 FC Accumulator Pressure Gauge*

NOTE: Always crosscheck the HYD 2 caution light subsequent to RAT extension. There is a possibility that RAT extension was the result of momentary high demand on the HYD 2 EDP and not pump failure. In this case, the HYD 2 light will extinguish at EDP pressure of 2000 psi and HYD 2 can be reset.

3. Aircraft exterior

   a. Left main wheelwell: HYD 2 FC accumulator pressure gauge identical to HYD 1 FC accumulator pressure gauge

      (1) Indicates pressure in HYD 2 FC accumulator (accumulator pressure, as opposed to system output pressure read from HYD 2 pressure gauge in cockpit)

      (2) Calibrated from 0 to 4000 psi increments and labeled every 1000 psi

      (3) When hydraulic fluid supply is depleted from accumulator, gauge displays nitrogen pressure only

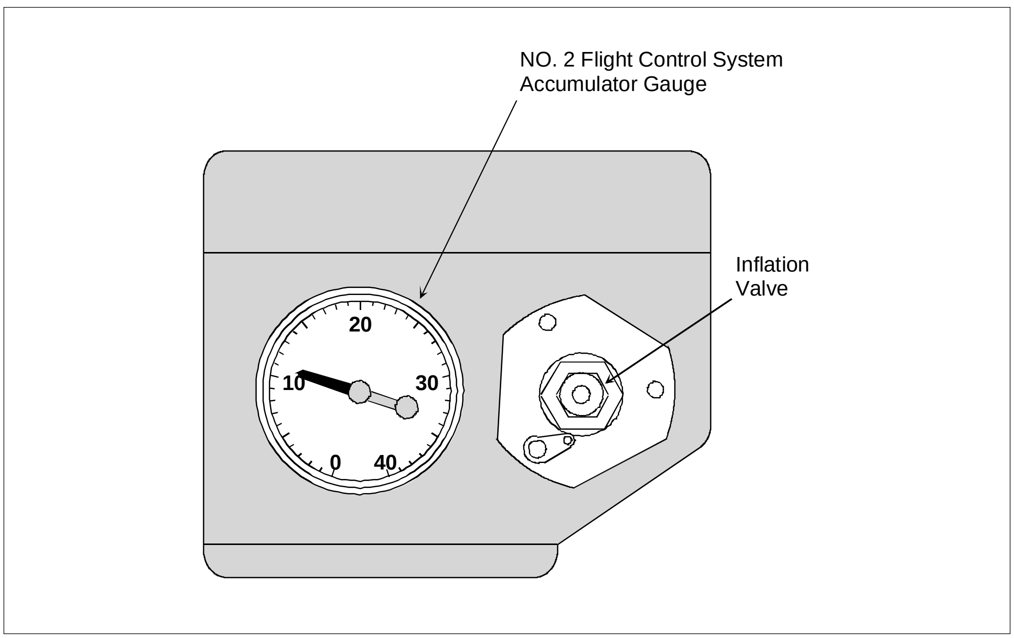


Figure 8: HYD 2 FC ACCUMULATOR PRESSURE GAUGE

Sg 3, fr 12
Fig 9: *Left Side External Locator*

b. Aft fuselage (left side)

(1) HYD 2 filter indicators: identical to HYD 1 filter indicators

(a) Two indicators, forward one for pressure line and aft one for return line

(b) Service required when red band visible

NOTE: The indicator protrudes (pops out), exposing the red band, when filter is clogged and the internal bypass valve opens.

NOTE: Indicator occasionally pops out due to pressure fluctuations or g forces encountered during hard landings.

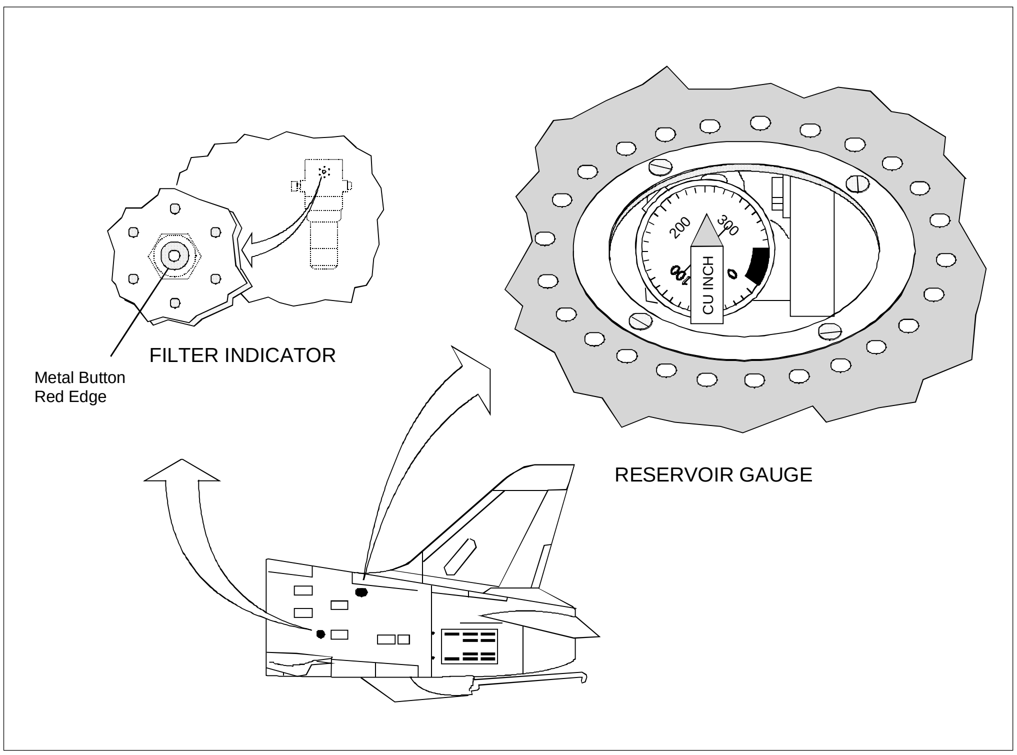


Figure 9: LEFT SIDE EXTERNAL LOCATOR

(2) HYD 2 reservoir indicator

(a) Indicates quantity of HYD 2 reservoir

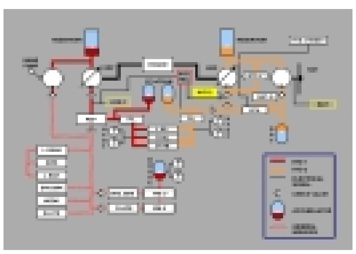
(b) Quantity will vary according to temperature of fluid and pressure in system

(c) Calibrated 0 to 340 cubic inches in 10 cubic-inch increments and labeled every 100 cubic inches

E. HYD 2 malfunctions

1. HYD 2 EDP output pressure falls below 1660 ± 110 psi

Sg 3, fr 13, p 1
Hydraulic System Block Diagram
(1 overlay)



a. If HYD 2 EDP output pressure drops below 1660 ± 110 psi for any reason (pump failure, excessive demand, engine flameout, or leak in system), pressure switch sends a signal to CWS

(1) MASTER ALERT light flashes

(2) HYD 2 caution light illuminates and caution tone sounds

(3) Hydraulic pressure is provided to flight control services as long as HYD 1 or RAT system remains operational

b. If HYD 2 EDP output pressure rises above 2000 psi, HYD 2 caution light will go out

LESSON NOTES

Explain that although the HYD 2 caution light extinguishes at 2000 psi, it may be illuminated with well over 2000 psi showing on the HYD 2 pressure gauge. This is because the gauge is indicating emergency hydraulic system pressure, from RAT output; however, both HYD caution lights indicate EDP output. The HYD FAIL warning light, unlike the caution lights, indicates low EDP pressure in both systems as well as low emergency hydraulic system pressure.

2. HYD 2 pressure falls below 1500 psi

Overlay 1

a. If HYD 2 pressure drops below 1500 psi, emergency package assembly in conjunction with the RAT accumulator deploys the RAT

NOTE: Should the HYD 2 light not be illuminated with the RAT light on, the HYD 2 lamp may be burned out. This failure can be confirmed by placing the MASTER TEST switch to LAMP.

b. If no leak in HYD 2, RAT will supply hydraulic backup pressure for HYD 2 services (ailerons and stabilator)

c. Regardless of RAT status, HYD 1 is providing primary power for the flight controls

F. HYD 2 operational characteristics summary **1.4.8.2.1**

HYD 2 is an independent hydraulic system used to power the flight control. The Emergency Hydraulic System provides HYD 2 redundancy when HYD 2 EDP pressure falls to approximately 1500 psi, regardless of the HYD 1 status. Landing approaches on RAT hydraulic power alone should not be attempted.

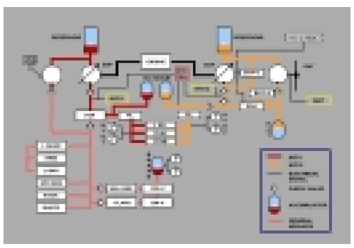
Sg 4, fr 2
Lesson Organization

HYDRAULIC SYSTEM
* T-45C hydraulic system overview
* Hydraulic system no. 1 (HYD 1)
* Hydraulic system no. 2 (HYD 2)
* **Emergency hydraulic system**
* Aircraft interfaces

IV. Emergency hydraulic system:

A. Description: the emergency hydraulic system acts as a backup to the HYD 2 system, by deploying the RAT when HYD 2 pressure falls below acceptable levels. The RAT automatically extends whenever HYD 2 EDP pressure falls below 1500 psi. Since the RAT is a fixed displacement pump, emergency hydraulic pressure will fluctuate between 2500 and 3000 psi displayed on the HYD 2 gauge, whenever the RAT is in operation

Sg 4, fr 3, p 1
Hydraulic System Block Diagram (3 overlays)



Overlay 1
Ram Air Turbine (RAT)

B. Emergency hydraulic system components

1. RAT

a. Location: RAT bay, aft fuselage behind gravity filler cap, forward of tail section

b. Functional: produces hydraulic pressure for emergency hydraulic system in event of HYD 2 EDP pressure loss.

c. Physical

(1) Consists of a variable pitch turbine, speed sensor, and fixed displacement hydraulic pump

NOTE: The RAT utilizes HYD 2 reservoir fluid to provide power for the emergency hydraulic system.

(2) Mounted on hinged support leg

(3) Raised into airstream automatically by hydraulic actuator when HYD 2 EDP pressure drops below 1500 psi

(4) Output volume and pressure vary with pump speed (fixed displacement pump)

(5) Speed limited by internal governor to 7300 rpm

2. RAT accumulator

Overlay 2
RAT Accumulator

a. Location: RAT bay, aft side

b. Description: carries nitrogen preload and provides hydraulic pressure to extend, and keep fully extended, the RAT actuator when HYD 2 EDP pressure drops below 1500 psi

c. Functional

(1) Stores hydraulic fluid under pressure to raise the RAT in event of HYD 2 pressure drop

(2) Provides backup supply of hydraulic pressure for flight controls during operation of the RAT

(3) Compensates for pressure fluctuations of the RAT

(4) Provides pressure to keep the RAT extended

d. Physical

(1) Includes a pressure regulating valve (cutout) and a cylinder with a free-floating piston that separates fluid from nitrogen

(2) Regulator valve cycles pressure between 2500 and 3000 psi, because the RAT is a fixed displacement pump whose output pressure is not internally regulated

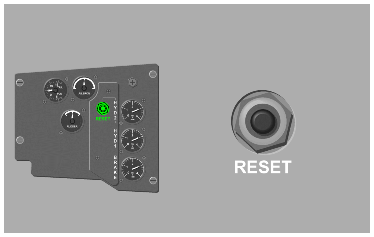
(3) Pressurized with nitrogen

3. Emergency package assembly

Overlay 3
Emergency Package Assembly

a. Functional: automatically deploys the RAT and directs Emergency Hydraulic System pressure to flight controls when HYD 2 pressure below 1500 psi

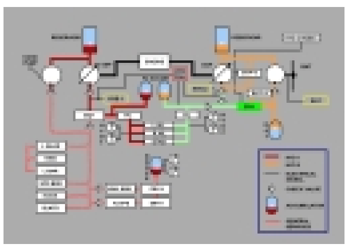
Sg 4, fr 5
HYD 2 RESET Button



b. Physical: thermal relief valve, spool valve, solenoid valve, restrictor

NOTE: The emergency package assembly isolates the HYD 2 EDP from the system when the RAT is deployed. To regain HYD 2 EDP pressure (and stow the RAT), the HYD 2 RESET button must be pressed.

Sg 4, fr 6, p 1
Hydraulic System Block Diagram (4 overlays)



C. Emergency hydraulic system: RAT

1. Deployment

a. Falling pressure in HYD 2 is sensed by the emergency package assembly

b. Emergency package assembly directs RAT accumulator pressure to RAT actuator, raising RAT into airstream

Overlay 1
RAT Actuator/RAT

2. Operation

NOTE: The capability of the RAT to provide hydraulic power for controllable flight during a total hydraulic pressure loss has not been determined. Safe ejection envelopes may be exceeded if control is lost during a landing attempt on emergency hydraulic power. Landing approaches on emergency hydraulic power alone should not be attempted.

a. RAT output regulated by cutout

(1) Cutout shuts off RAT output at rising pressure of 3000 psi

(2) Cutout connects output of RAT at falling pressure of 2500 psi

b. RAT charges accumulator

Overlay 2
RAT Accumulator

c. Supplies HYD 2 flight control services through emergency package assembly

3. If HYD 2 EDP is producing more than 1800 psi, and engine rpm is equal to or greater than 45%, HYD 2 RESET button can be used to retract RAT

Overlay 3
HYD 2 RESET

NOTE: The only indication of whether or not the HYD 2 EDP is producing adequate pressure to stow the RAT is the HYD 2 caution light extinguishing at approximately 2000 EDP psi.

4. Normal engine shutdown

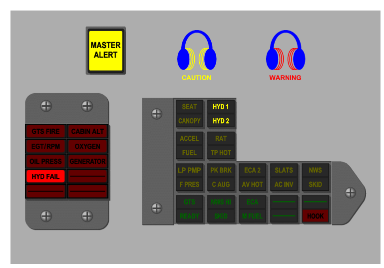
Overlay 4
RAT Shutdown

   a. RAT will extend when HYD 2 pressure drops below 1500 psi

   b. RAT will retract due to spring loading when HYD 2 pressure drops below 700 psi (air loads permitting)

D. Emergency hydraulic system malfunctions

Sg 4, fr 9
Warning and Caution Advisory Light Panel (1 overlay)



1. Failure of HYD 1 and HYD 2 combined with failure of the emergency hydraulic system to produce pressure will cause the HYD FAIL light to illuminate and warning tone sounds. Possible reasons for failure are:

Overlay 1
RAT Extend Caution Light

   a. Failure of RAT to extend at 1500 psi and HYD 2 pressure below 1660 $\pm$ 110 psi

   b. HYD 2 hydraulic system leakage (loss of fluid) associated with a HYD 2 caution light and caution tone

   c. Damage to RAT mechanism with RAT caution light and failure of HYD 2 pressure to cycle between 2500 and 3000 psi

2. Loss of all hydraulic pressure will result in loss of control of the aircraft

E. Emergency hydraulic system summary:

The emergency hydraulic system acts as a backup to HYD 2 in the event of a HYD 2 pressure loss. It is able to maintain pressure to provide power to the flight controls. RAT deploys regardless of the condition of the HYD 1 and/or the HYD 2 EDP, whenever HYD 2 pressure decreases below 1500 psi. The following major components enable the emergency hydraulic system to perform this function: the ram air turbine (RAT), the RAT accumulator, the HYD 2 reservoir, and the emergency package assembly

PROGRESS CHECK

Question 1 — 1.4.8.3.1
What is the function of the emergency hydraulic system and when does it activate?

ANSWER: The emergency hydraulic system acts as a backup to the HYD 2 EDP. If the HYD 2 EDP is unable to maintain sufficient pressure for any reason and HYD 2 EDP pressure falls below 1500 psi, the RAT will deploy and provide emergency hydraulic power to the HYD 2 side of the flight controls.

PROGRESS CHECK

Question 2 — 1.4.8.2.1, 1.4.8.3
What information do the HYD 1, HYD 2, and BRAKE pressure gauges provide and what should they display when the hydraulic system is functioning normally?

ANSWER:
1. HYD 1 indicates HYD 1 system pressure as provided by the HYD 1 EDP. If HYD 1 is functioning normally, it should indicate 3000 psi.
2. HYD 2 indicates HYD 2 system pressure as provided by the HYD 2 EDP or the Emergency Hydraulic System. If HYD 2 EDP is functioning normally, it should indicate 3000 psi. If the emergency hydraulic system is functioning normally, it should fluctuate between 2500 and 3000 psi.
3. BRAKE indicates the nitrogen preload pressure in the wheel brake/emergency flap accumulator. If the accumulator is functioning normally, it should indicate 3000 psi when HYD 1 is operating and approximately 2800 psi when the engine is shut down.

V. Aircraft interfaces **1.4.8.2**

A. Inputs

1. Electrical system: all Warnig and caution advisory panels lights, HYD 2 RESET button, and system solenoid valves supplied by 28 VDC essential services bus

2. Engine accessory gearbox: provides mechanical power to drive two hydraulic pumps

B. Output

1. HYD 1

a. Flight controls supplied continuously

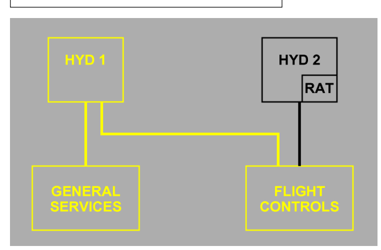
(1) Ailerons

Sg 11, fr 2
Lesson Organization

HYDRAULIC SYSTEM

* T-45C hydraulic system overview
* Hydraulic system no. 1 (HYD 1)
* Hydraulic system no. 2 (HYD 2)
* Emergency hydraulic system
* **Aircraft interfaces**

Sg 11, fr 3, p 1
Simplified Hydraulic System Block Diagram (2 overlays)



(2) Stabilator

NOTE: Rudder is mechanical and does not receive hydraulic power.

b. General services when HYD 1 pressure is above 1600 psi

(1) Landing gear

(2) Nose wheel steering

(3) Launch bar

(4) Speed brakes

(5) Arresting hook

(6) Flaps and slats

(7) Wheel brakes and anti-skid

Overlay 1
HYD 2 System

2. HYD 2 and emergency package assembly

a. Ailerons

b. Stabilator

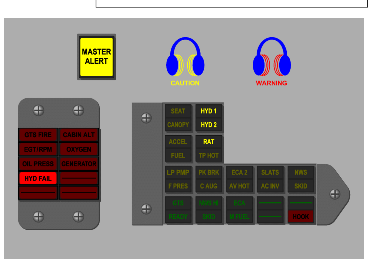
Overlay 2
RAT System

3. Emergency hydraulic system

a. RAT supplies pressure using HYD 2 system fluid

b. Backup for HYD 2 EDP pressure to ailerons and stabilator

Sg 11, fr 5
Warning and Caution Advisory Light Panels



c. CWS: MASTER ALERT light flashes concurrently with illuminated HYD FAIL warning light and HYD 1, HYD 2, and RAT caution lights

NOTE: RATcaution light may or may not be illuminated with HYD FAIL warning light.

d. Intercom system (ICS): caution tone sounds in headset concurrently with Warning and caution advisory panel indications of HYD , HYD 2, and RAT caution lights; warning tone sounds with HYD FAIL warning light

PROGRESS CHECK

Question 3 — 1.4.8.2
From the list below,

1. **Which items are provided hydraulic power by both HYD 1 and HYD 2;**
2. **Which items are provided hydraulic power by HYD 1 only;**
3. **Which items are not powered by either HYD 1 or HYD 2?**

a. Landing Gear/Gear Doors
b. Speed Brakes
c. Ailerons
d. Nose Wheel Steering
e. Flaps/slats
f. Wheel/Parking Brakes
g. Arresting Hook
h. Stabilator
i. Rudder
j. Launch Bar

ANSWER:

1. HYD 1 and HYD 2 power items c and h.
2. HYD 1 provides power to items a, b, d, e, f, g, and j.
3. Neither HYD 1 nor HYD 2 power item i.

Sg 10, fr 2/3
Review Menu

SUMMARY

The T-45C has two hydraulic systems (HYD 1 and HYD 2) which operate independently of one another to power the flight controls. Additionally, HYD 1 powers general services. HYD 1 is the larger of the two and provides hydraulic power to the flight controls (ailerons and stabilator) and general services (flaps, slats, speed brakes, NWS, landing gear/gear doors, wheel/parking brakes, launch bar, arresting hook). HYD 2 supplies hydraulic power to the flight controls and emergency package assembly.

Both systems are powered by EDPs that produce a constant output pressure of 3000 psi. If either system fails, the other system has enough hydraulic power to operate the flight controls. Additionally, the Emergency Hydraulic System acts as a backup to HYD 2 if the HYD 2 EDP is unable to maintain sufficient pressure. Because the RAT is not designed to provide constant pressure levels, control responses may be sluggish if only the RAT is operating. If HYD 2 fails, HYD 1 will of course maintain pressure to the flight controls and the general services. However, if HYD 1 fails, HYD 2 is designed to power only the flight controls. The general services will rely on emergency backup systems, if available.

Because output pressure in both hydraulic systems is continuously monitored, a malfunction in the hydraulic system is relayed to the CWS, which then causes the MASTER ALERT light to flash, sounds either the warning or caution tone, and illuminates the appropriate warning/caution lights on the Warning and caution advisory panels.

Cockpit controls and indicators include the HYD 1 and HYD 2 pressure gauges, the BRAKE pressure gauge, the the HYD 2 RESET button, and the following warning and caution lights on the WCP: HYD 1, HYD 2, RAT, and HYD FAIL. Additionally, there are several indicators on the exterior of the aircraft (the wheel brake/emergency flap accumulator pressure gauge, HYD 1/ HYD 2 FC accumulator pressure gauges, HYD 1/HYD 2 filter indicators, and the HYD 1/HYD 2 reservoir indicators.

CONCLUSION

Knowing how the hydraulic system operates and recognizing the significance of cockpit indications are critical to completing your flight successfully and returning with your aircraft.

NOTES

LECTURE GUIDE

COURSE/STAGE: TS, ADV & IUT / Engineering

LESSON TITLE: Hydraulic System Malfunctions

LESSON IDENTIFIER: T-45C TS, ADV & IUT ENG-10

LEARNING ENVIRONMENT: CAI

ALLOTTED LESSON TIME: 1.0 hr

TRAINING AIDS:

* Figures
  Fig 1: Hydraulic System
  Fig 2: Caution Advisory Panel
  Fig 3: Hydraulic Pressure Gauges
  Fig 4: Indications Summary

STUDY RESOURCES:

* T-45C NATOPS Flight Manual, A1-T45AC-NFM-000

LESSON PREPARATION:

Read:
* Part I, Chapter 2.5, "Hydraulic System," T-45C NATOPS Flight Manual, A1-T45AC-NFM-000
* Part V, concerning hydraulic system malfunctions, T-45C NATOPS Flight Manual, A1-T45AC-NFM-000

Review:
* Lesson Guide for Eng-09, "Hydraulic System"

(9-98) CHANGE 2

REINFORCEMENT: N/A

LESSON EXAMINATION:

Student is required to read hydraulic system and related malfunction paragraphs in the NATOPS Flight Manual, receive classroom instruction, and complete assigned CAI lesson(s). The student shall demonstrate knowledge by completing, from memory with 80% accuracy, true/false and multiple choice block examinations. The objectives in this lesson will be tested in either Engineering 29X or Engineering 30X.

LESSON OBJECTIVES

1.8.1.5.2.1
Identify indications of uncommanded RAT extension

1.8.1.5.8.1
Identify indications of HYD 1 and 2 accumulator failures

1.8.1.5.6.1
Identify indications of HYD 1 slow loss of pressure

1.8.1.5.7.1
Identify indications of HYD 2 slow loss of pressure

1.8.1.5.4.1
Identify indications of HYD 1 EDP failure

1.8.1.5.5.1
Identify indications of HYD 2 EDP failure

1.8.1.5.1.1
Identify indications of RAT failure

1.8.1.5.9.1
Identify indications of HYD 1 and 2 failure (RAT operating)

1.8.1.5.3.1
Identify indications of total hydraulic failure

MOTIVATION

Your flight control surfaces are hydraulically operated--with no mechanical backup. Any hydraulic system failure is serious. In the worst case--if you lose all hydraulic power--the airplane is unflyable.

These malfunctions may not occur in isolation; one might well cause another. These CAI lessons teach you only the indications of each malfunction and their associated safety implications. Emergency procedures are taught later in the curriculum.

OVERVIEW

This lesson is intended to familiarize you with the indications of malfunctions that could occur in the T-45C hydraulic system. In addition, you will learn how to verify the indications (if necessary) and what each malfunction means in terms of aircraft operation and flight safety.

Specific procedures for emergencies are not discussed directly in this lesson, although some may be obvious. Later in your training, you will learn exactly what to do in response to these malfunctions. In the simulator, you will be expected to recognize the indications you learn today and to take the correct action.

This lesson presents indications of the following hydraulic system malfunctions:

* Uncommanded ram air turbine (RAT) extension
* Flight control accumulator failure
* HYD 1 and HYD 2 slow pressure loss
* HYD 1 and HYD 2 hydraulic pump failure
* RAT failure
* HYD 1 and HYD 2 failure (RAT operating)
* Total system failure

REFRESHER

* Recall the location and function of cockpit hydraulic indicators and switches, warning and caution advisory panel and master alert light.
* Recall the warning and caution advisory lights associated with the hydraulic system.

PRESENTATION

I. Uncommanded ram air turbine (RAT) extension

Fig 1: *Hydraulic System*

Fig 2: *Caution Advisory Panel*

A. Indications

1. RAT caution light illuminated

2. HYD 2 caution light not illuminated

NOTE: The RAT should extend only when HYD 2 pressure drops to approximately 1500 psi. The HYD 2 caution light should illuminate at 1660 +/- 110 psi, before the RAT deploys.

B. Verifications

1. Visual confirmation

2. Setting LIGHT/TONE TEST switch to LIGHT TEST position verifies that HYD 2 light is operable

3. RAT may be reset

NOTE: With engine at 45% rpm or more, the HYD 2 RESET button may retract the RAT as long as HYD 2 EDP is operational and pressure is above 1800 psi.

C. Effects on flight safety: if RAT not operating, then no flight control backup if HYD 2 fails

II. Flight control accumulator failure

Fig 1: *Hydraulic System*

A. Indications

1. Ground: absence of adequate accumulator pressure during preflight

NOTE: The accumulator gauges for both systems are located in the main wheelwells--system 1 on the right, system 2 on the left. Each gauge should show 1100 +/- 50 psi.

2. In flight

a. Both systems, including accumulators, supply continuous hydraulic power to flight controls

b. With systems operating normally, no indication of a single accumulator failure: if one accumulator fails, then redundant accumulator provides adequate pressure damping and reserve power

Fig 3: Hydraulic Pressure Gauges

Fig 2: Warning and Caution Advisory Light Panel

c. If aircraft operating on only one system and that system's accumulator fails or if both accumulators fail at once, then controls rely on EDP pressure only

(1) Flight controls may not respond smoothly

(2) Momentary loss of normal control on high demand

B. Verifications: erratic flight control response during periods of high demand (a large or rapid control stick displacement)

C. Effects on flight safety

1. If both accumulators fail, controls rely on EDP pressure only

2. High systems demand maneuvering could result in rough control responses and possible loss of maneuverability

III. HYD 1 and HYD 2 slow pressure loss

A. Indications: in flight, pressure in either system is lower than normal or visibly decreasing, as indicated by HYD 1 or HYD 2 pressure gauges in both cockpits

B. Verifications

1. HYD 1

a. Pressure continues decreasing

b. At approximately 1500 psi, loss of general services (e.g., speed brake) noted

c. At 600 +/- 50 psi

(1) MASTER ALERT light flashes

(2) Caution tone sounds

(3) HYD 1 caution light illuminates

2. HYD 2

a. Pressure continues decreasing

b. At 1660 +/- 110 psi

(1) MASTER ALERT light flashes

(2) Caution tone sounds

(3) HYD 2 caution light illuminates

c. After pressure has dropped below 1500 $\pm$ 100 psi, RAT will deploy and the RAT caution light will illuminate

d. If pressure drop due to fluid loss, pressure may temporarily rise and cycle after RAT extends but then will continue to drop

NOTE: The HYD 1 & 2 caution lights indicate EDP pressure only. Since the EDP is the sole source of hydraulic pressure in the HYD 1 system, the HYD 1 gauge normally reflects the serviceability of the pump. The only exception to this would be loss of pressure due to hydraulic fluid leakage. The HYD 2 gauge shows system pressure resulting from either the HYD 2 EDP or the Emergency Hydraulic System. Neither the pump or the RAT will maintain HYD 2 pressure if a system leak depletes HYD 2 system reservoir. Should HYD 2 fluid depletion result in less than 700 psi system pressure, spring tension will cause the RAT to automatically retract, however, in-flight aerodynamic loading may prevent retraction.

C. Effects on flight safety

1. HYD 2 or Emergency Hydraulic System maintains hydraulic pressure for flight controls if HYD 1 fails

2. HYD 1 maintains pressure for flight controls if HYD 2 fails

3. If pressure loss is in HYD 1, normal operation is lost for landing gear, brakes, flaps, slats, hook, speed brakes, nose wheel steering (NWS), and launch bar

NOTE: Proper use of emergency backup systems for these services is covered in NATOPS and is the subject of future lessons.

4. Loss of fluid in both systems would render aircraft unflyable

IV. HYD 1 and HYD 2 hydraulic pump failure

Fig 1: *Hydraulic System*

A. Indications

1. HYD 1

a. Low pressure or rapid pressure loss, as indicated by HYD 1 pressure gauge

b. Possible noise and vibration associated with deteriorating pump

c. CWS and auditory cautions noted (pressure below 600 $\pm$ 50 psi)

2. HYD 2

   a. Rapid pressure loss, as indicated by HYD 2 pressure gauge

   b. Possible noise and vibration associated with deteriorating pump

   c. CWS indications activate at 1660 ± 110 psi

   d. RAT extends at approximately 1500 psi, and HYD 2 pressure gauge indicates Emergency Hydraulic System pressure cycling between 2500 and 3000 psi

      NOTE: Compare this to the indications associated with fluid loss, as discussed earlier. Notice that if the failure of HYD 2 results from an EDP failure (with no leak), then pressure is supplied by the RAT. If the failure includes a complete or continuing loss of fluid, then cycling pressure (indicative of RAT operation) may be only temporary, if it occurs at all.

B. Verifications

1. For HYD 1, loss of normal operation of landing gear, brakes, flaps, slats, hook, speed brakes, NWS, and launch bar

2. For HYD 2, RAT continues to operate normally—i.e., pressure continues to fluctuate between approximately 2500 and 3000 psi

3. If pump failure is associated with leak, fluid loss may be visible to pilot or another aircraft

4. HYD 2 caution light ON

C. Effects on flight safety

1. Aircraft operating without flight control redundancy

2. Loss of general services

V. RAT failure

A. Failure to extend

1. Indications

   a. HYD 2 pressure falls below 1500 ± 100 psi

   b. MASTER ALERT has flashed, caution tone has sounded, and HYD 2 caution light is illuminated

***Fig 2:** Warning and Caution Advisory Light Panel*

2. Verifications

a. No HYD 2 pressure fluctuation (between 2500 and 3000 psi)

b. RAT caution light not illuminated

c. Visual confirmation from another aircraft

(1) RAT not extended

(2) RAT extended and spinning but still no pressure

B. Failure to operate

1. Indications

a. RAT extended, RAT caution light illuminated

b. Pressure below 1500 psi

2. Verifications

a. RAT seen extended by another aircraft

b. Turbine not spinning

C. Effects on flight safety

1. With RAT failure, no emergency backup for flight controls available if HYDs 1 and 2 fail

2. Possible hydraulic leak

VI. HYD 1 and HYD 2 failure (RAT operating)

A. Indications

1. MASTER ALERT light flashes

2. Caution tone sounds

3. HYD 1 caution light illuminated

4. HYD 2 caution light illuminated

5. RAT caution light illuminated

B. Verifications

1. HYD 1 pressure reads below 600 +/- 50 psi

2. HYD 2 pressure gauge shows cycling pressure (between 2500 and 3000 psi)

Fig 4: *Indications Summary*

C. Effects on flight safety

1. Aircraft flight controls depend on Emergency Hydraulic System only; aircraft is unflyable if RAT fails

2. Aircraft control responses may be reduced on high demand

3. Normal landing gear, flaps, slats, wheel brakes, arresting hook, speed brakes, NWS, and launch bar inoperative

VII. Total system failure

A. Indications

1. MASTER ALERT light flashes

2. Caution and then warning tone sounds

3. HYD 1 and HYD 2 caution lights illuminated

4. RAT caution light illuminates, then may go off

5. HYD FAIL warning light illuminates

6. No cycling of pressure on HYD 2 gauge

Fig 4: *Indications Summary*

B. Verifications: gauges show little or no pressure

NOTE: If the HYD 2 pressure gauge indicates no cycling of pressures, either a significant hydraulic fluid loss or an EDP failure combined with an inoperative RAT has occurred.

C. Effects on flight safety: total failure unlikely but an extreme emergency-flight controls will be inoperative when accumulator is exhausted

SUMMARY

This lesson has presented indications of these hydraulic system malfunctions:

* Uncommanded RAT extension
* Flight control accumulator failure
* HYD 1 and HYD 2 slow pressure loss
* HYD 1 and HYD 2 hydraulic pump failure
* RAT failure
* HYD 1 and HYD 2 failure (RAT operating)
* Total system failure

CONCLUSION

Being able to recognize aircraft system malfunctions quickly is critical to your making safe and logical decisions in an emergency.

The conditions described in this lesson might occur in conjunction with each other or with some malfunction related to another aircraft system.

If this lesson has raised any questions for you, be certain to contact your instructor.

FIGURES

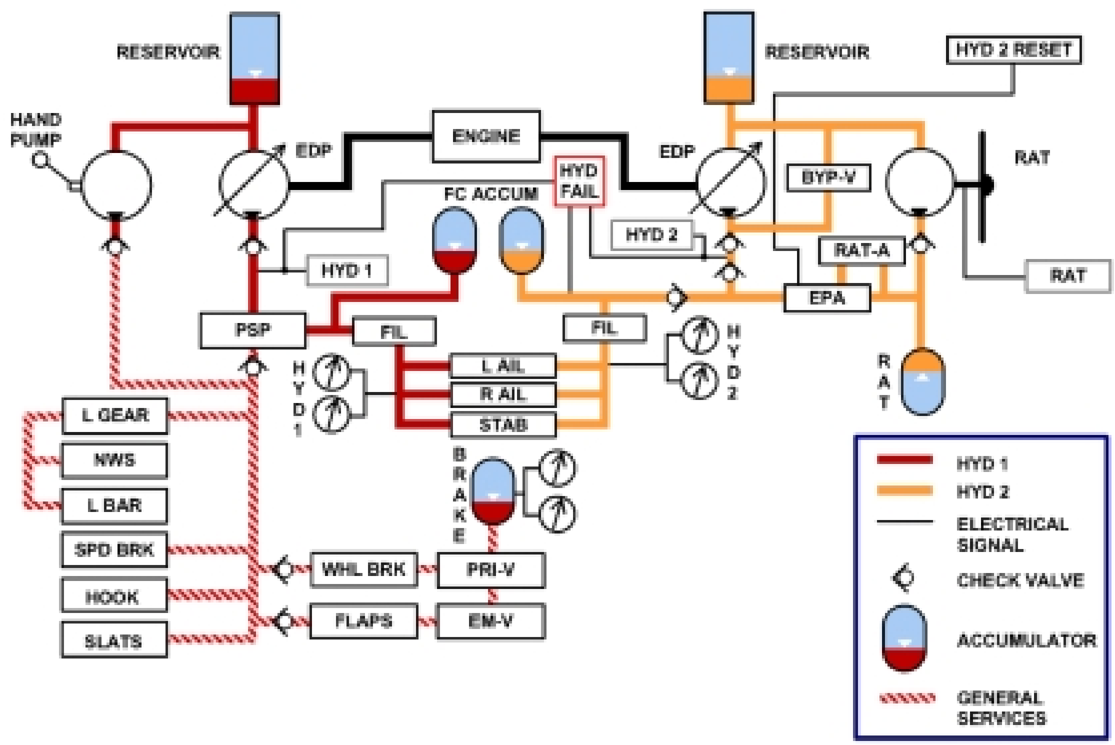


Figure 1: HYDRAULIC SYSTEM

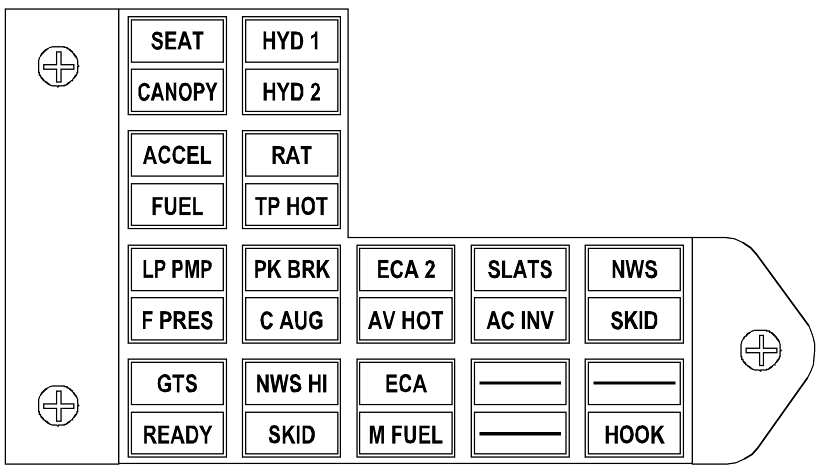


Figure 2: CAUTION ADVISORY PANEL

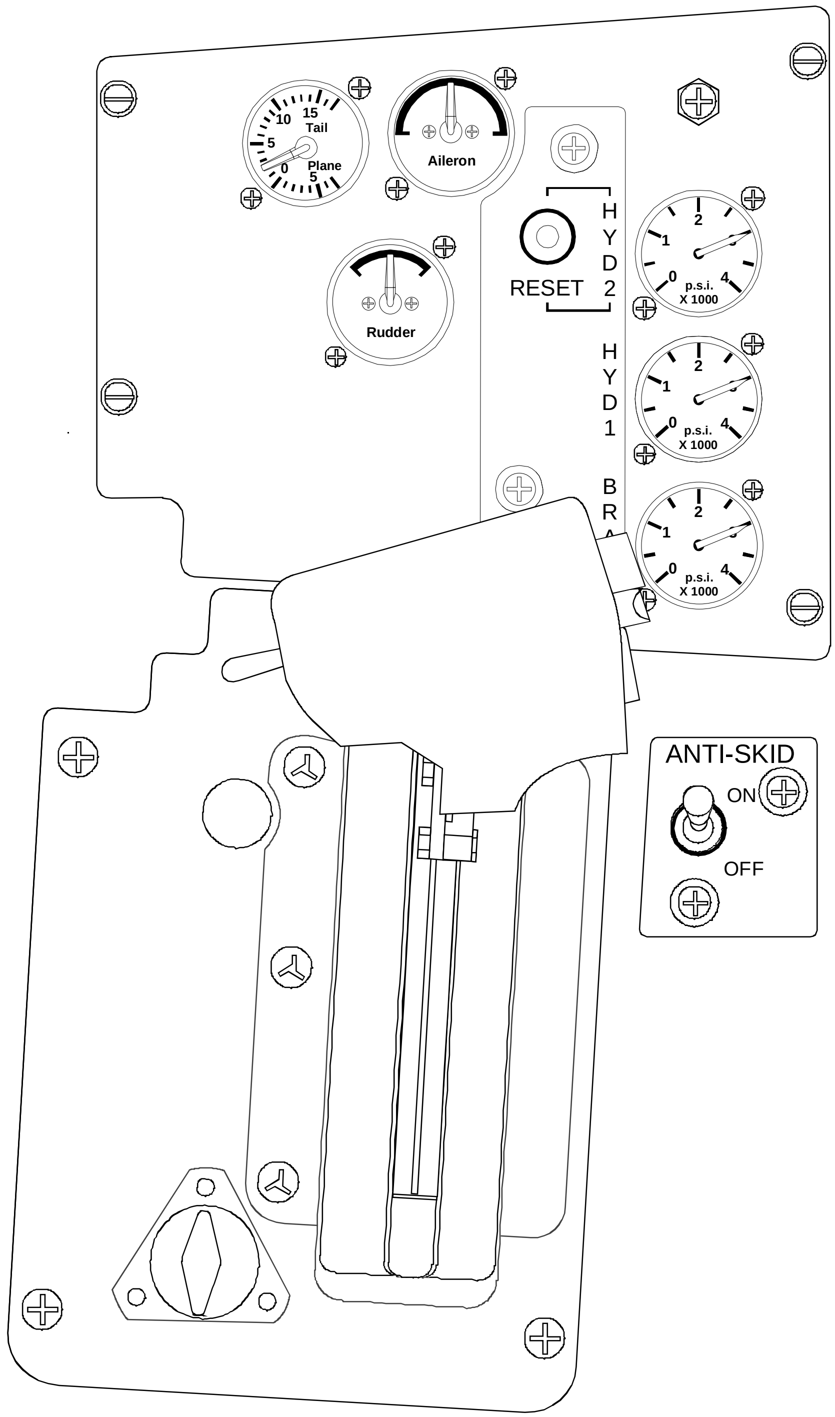


Figure 3: HYDRAULIC PRESSURE GAUGES

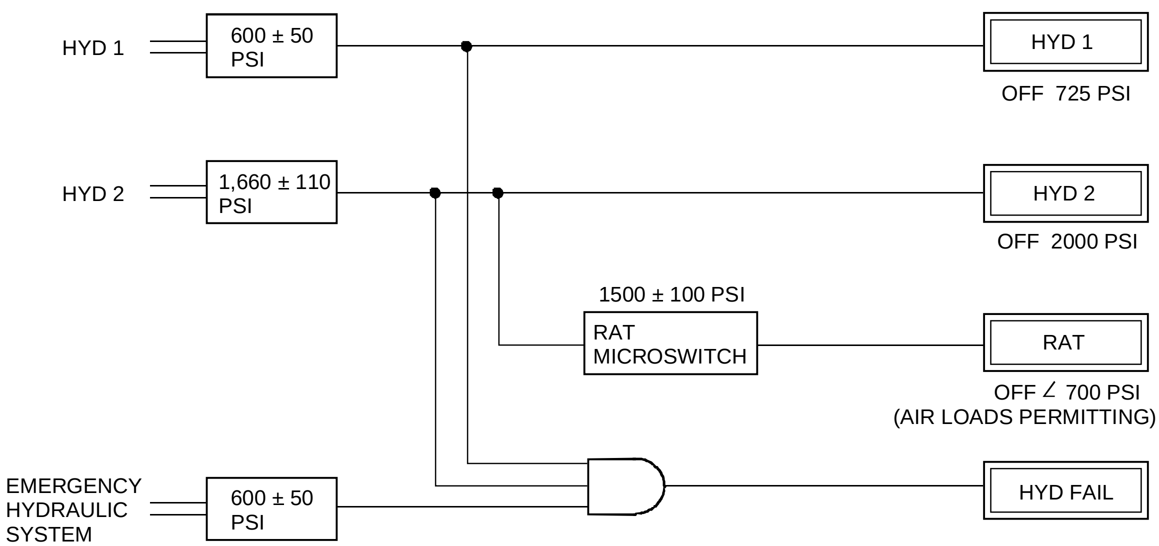


Figure 4: INDICATIONS SUMMARY

NOTES

LECTURE GUIDE

COURSE/STAGE: TS, ADV & IUT / Engineering

LESSON TITLE: Hydraulic Subsystems

LESSON IDENTIFIER: T-45C TS, ADV & IUT ENG-11

LEARNING ENVIRONMENT: Classroom

ALLOTTED LESSON TIME: 1.8 hr

TRAINING AIDS:

* Figures
  - Fig 1: Main Landing Gear (MLG) Major Components
  - Fig 2: MLG Pin
  - Fig 3: Landing Gear Doors
  - Fig 4: Nose Landing Gear (NLG) Major Components
  - Fig 5: Landing Gear Controls and Indicators
  - Fig 6: NLG Strut Pressure Gauges
  - Fig 7: NLG Strut Inflation Chart
  - Fig 8: Landing Gear Indications
  - Fig 9: Hydraulic System Block Diagram
  - Fig 10: Wheel Brake/Anti-Skid System Block Diagram
  - Fig 11: Brake System Controls and Indicators
  - Fig 12: Wheel Brake/Emergency Flap Accumulator Pressure Gauge
  - Fig 13: Anti-Skid System Controls and Indicators
  - Fig 14: Brake Unit Inspection
  - Fig 15: Nose Wheel Steering (NWS) System Major Components
  - Fig 16: NWS System Controls and Indicators

TRAINING AIDS (cont):

Fig 17: NWS System Component Locator
Fig 18: Launch Bar System Major Components
Fig 19: Launch Bar System Controls and Indicators (FWD Cockpit)
Fig 20: Arresting Hook System Major Components
Fig 21: Arresting Hook Inspection
Fig 22: Arresting Hook System Controls and Indicators (FWD Cockpit)
Fig 23: Arresting Hook Operation
Fig 24: Centralized Warning System Interface
Fig 25: Weight-On-Wheels (WOW)

STUDY RESOURCES:

* <u>T-45C NATOPS Flight Manual</u>, A1-T45AC-NFM-000

LESSON PREPARATION:

Read:

* Part I, Chapter 2.8 “Landing Gear System,” 2.9 “Nose Wheel Steering System,” 2.10 “Wheel Brake/Anti-Skid System,” 2.11 “Launch Bar System,” and 2.12 “Arresting Hook System,” <u>T-45C NATOPS Flight Manual</u>, A1-T45AC NFM-000

REINFORCEMENT: N/A

EXAMINATION:
Student is required to read hydraulic system and related malfunction paragraphs in the NATOPS Flight Manual, receive classroom instruction, and complete assigned CAI lesson(s). The student shall demonstrate knowledge by completing, from memory with 80% accuracy, true/false and multiple choice block examinations. The objectives in this lesson will be tested in either Engineering 29X or Engineering 30X.

LESSON OBJECTIVES

1.5.4.1.1.1
Recall operating characteristics/limitations of the landing gear system

1.5.4.1.1.1.1
Locate landing gear controls and indicators

1.4.10.3.1
Recall major components of the brake system

1.4.11.3.1
Recall major components of the anti-skid system

1.4.10.3
Recall function, purpose, and location of brake system controls, switches, and indicators

1.4.11.3
Recall function, purpose, and location of anti-skid system controls, switches, and indicators

1.4.10.2.1
Recall operating characteristics of the brake system

1.4.11.2.1
Recall operating characteristics of the anti-skid system

1.4.9.3.1
Recall major components of the nose wheel steering system

1.4.9.3
Recall function, purpose, and location of nose wheel steering controls, switches, and indicators

1.4.9.2.1
Recall operating characteristics of the nose wheel steering system

1.4.12.3.1
Recall major components of the launch bar system

1.4.12.3
Recall function, purpose, and location of launch bar system controls, switches, and indicators

1.4.12.2.1
Recall operating characteristics of the launch bar system

1.4.13.3.1
Recall major components of the tail hook system

1.4.13.3
Recall function, purpose, and location of tail hook system controls, switches, and indicators

1.4.13.2.1
Recall operating characteristics of the tail hook system

1.4.9.2
Recall interfaces between the nose wheel steering system and other a/c systems

1.4.12.2
Recall interfaces between the launch bar system and other a/c systems

1.4.10.2
Recall interfaces between the brake system and other a/c systems

1.4.11.2
Recall interfaces between the anti-skid system and other a/c systems

1.4.13.2
Recall interfaces between the tail hook system and other a/c systems

MOTIVATION

Knowledge of aircraft hydraulic subsystems characteristics and operations is critical to safe flying.

OVERVIEW

In this lesson we will build on your understanding of the T-45C hydraulic system. For the T-45C, you will learn the purpose, functional characteristics, and components of--and the location of controls for--the hydraulic subsystems and the interfaces between them and other T-45C systems.

In this lesson we will be covering the:

* Physical characteristics, functional descriptions, and operating limitations of the major components of the hydraulic subsystems, including the nose- and main-landing gear, nose wheel steering (NWS), launch bar, wheel brake anti/skid, and arresting hook systems
* Purpose, function, and location of hydraulic subsystems cockpit controls and indicators
* Interfaces between hydraulic subsystems and other T-45C systems

REFRESHER

Recall that:

* In addition to flight controls, HYD 1 supplies 3000 psi pressure to operate all the “general services” hydraulic requirements in the T-45C

Sg 1, fr 2
Lesson Organization

HYDRAULIC SUBSYSTEMS

* **Landing gear system**
* Landing gear-related components
* Aircraft interfaces

Sg 1, fr 3
***Fig 1:** Main Landing Gear (MLG) Major Components*

PRESENTATION

I. Landing gear system **1.5.4.1.1.1**, **1.5.4.1.1.1.1**

A. Major components

1. Main landing gear (MLG)

a. Shock strut: mechanically connects shock absorbing piston tube, side brace, retraction actuator, and trailing arm

b. Piston tube (also known as an oleo): shock absorber to cushion force of landing

NOTE: Approximately 7/8 to 1 7/8 inches of exposed chrome required for normal wheel strut (aircraft at 13,000 lbs).

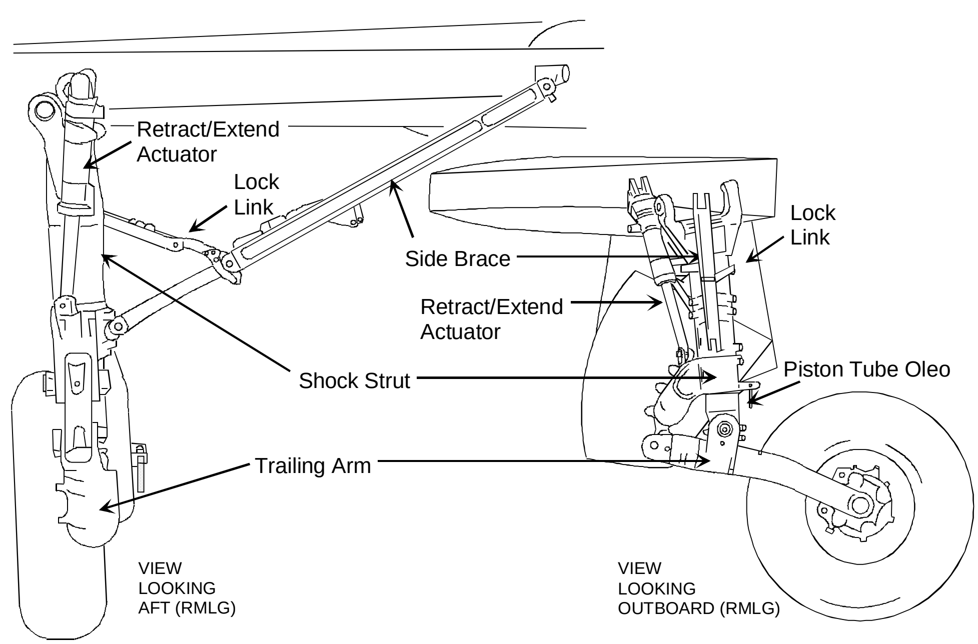


Figure 1: MAIN LANDING GEAR (MLG) MAJOR COMPONENTS

c. Trailing arm

(1) Mount for axle, wheel, and brake unit

(2) Connects to shock absorber piston tube to absorb shock loads from landing

d. Retract/extend actuator: retracts and extends main gear

e. Side brace

(1) Provides lateral support for MLG

(2) Serves as mount for lock link device

(3) Stripes on side brace provide visual indication of MLG fully extended

f. Lock link: mechanically locks gear down

(1) Gear safety pins location

Sg 1, fr 4
Fig 2: *MLG Pin*

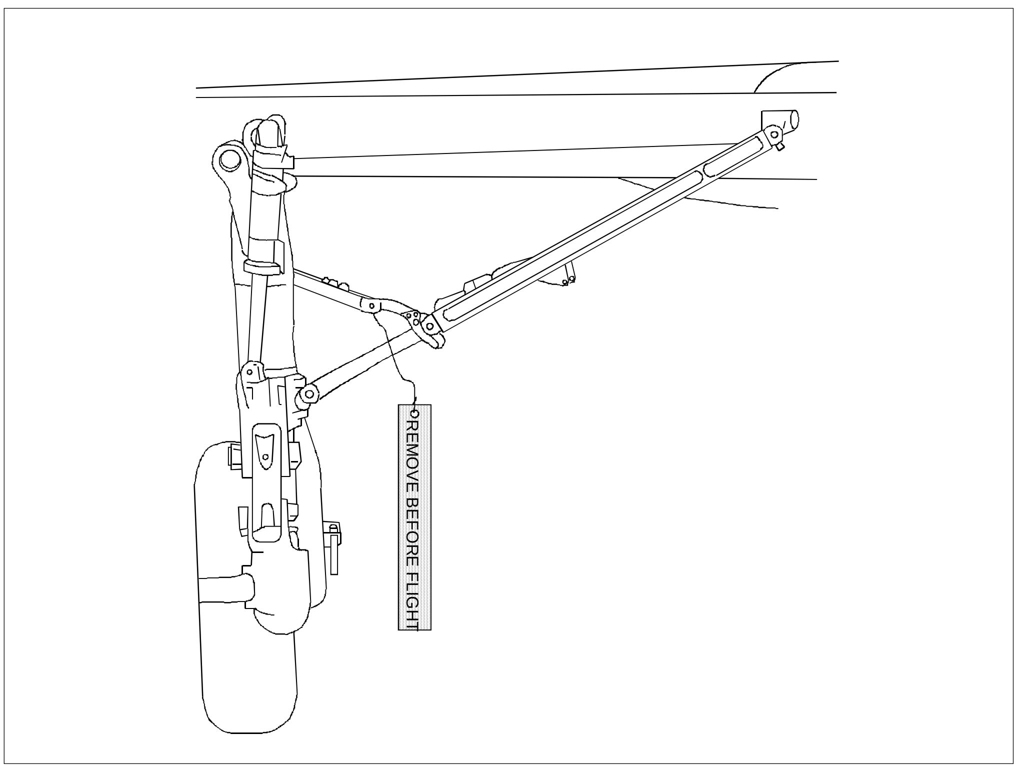


Figure 2: MLG PIN

Sg 1, fr 5
MLG Doors
Fig 3: *Landing Gear Doors*

g. Inner (wheelwell) door

(1) Electromechanically controlled, hydraulically operated

(2) Opens to let gear down, then closes and locks to reduce chance of fouling on arresting gear

(3) Remains open if gear extended with emergency gear extension system

h. Trunnion door

(1) Mechanically operated by gear motion

(2) Remains open when gear extended

i. Trailing arm door

(1) Physically connected to trailing arm

(2) Remains open when gear extended

j. Fixed strut door

(1) Physically connected to fixed strut

(2) Remains open when gear extended

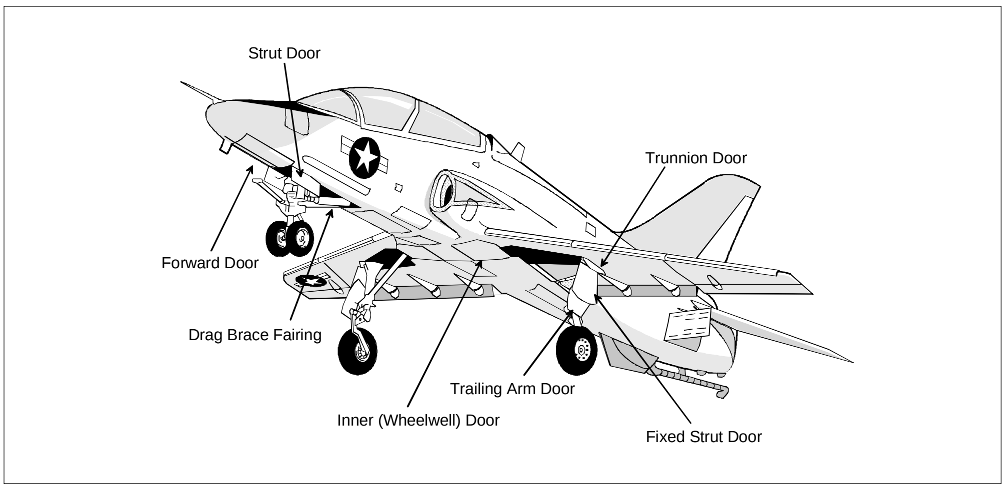


Figure 3: LANDING GEAR DOORS

Sg 1, fr 6
Fig 4: *Nose Landing Gear (NLG) Major Components*

2. Nose landing gear (NLG)

   a. Shock strut

      (1) Oleo-pneumatic (nitrogen-charged) shock absorber

      (2) Cushions aircraft from loads occurring during catapult operations and landings

   b. Launch bar: physically connects to carrier deck shuttle to transfer energy from catapult to aircraft during catapult launches

   c. Drag brace

      (1) Transfers catapult load to airframe during tension prior to runup and catapult launch

      (2) NLG drag brace lock indicator

   d. Holdback fitting

      (1) Mechanically connects to catapult holdback on deck

      (2) Physically holds aircraft for engine runup prior to launch

      (3) Reusable

   e. Retract/extend actuator: hydraulically powered piston retracts and extends nose gear

   f. Approach light: AOA indication for LSO

   g. Land/taxi light assembly: houses high-intensity landing/taxi light

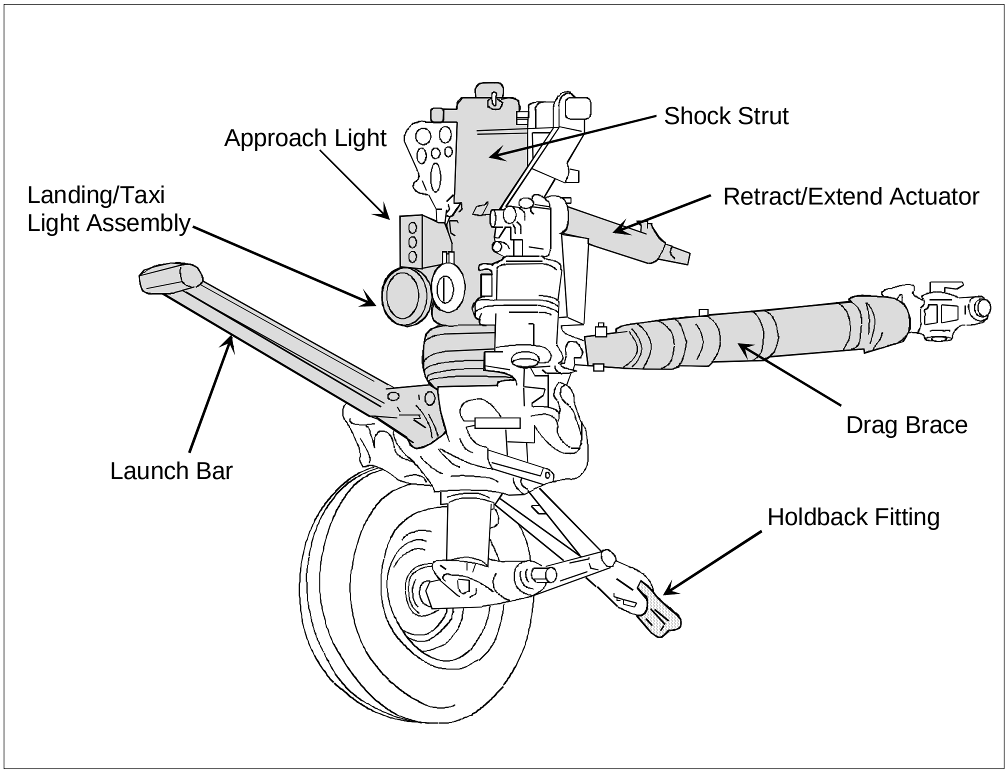
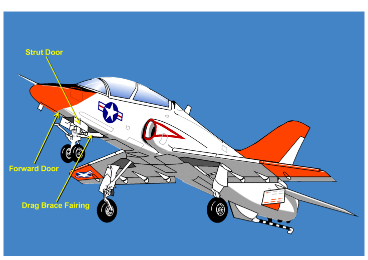


Figure 4: NOSE LANDING GEAR (NLG) MAJOR COMPONENTS

Sg 1, fr 7
NLG Doors
Landing Gear Doors



h. Forward doors--two

(1) Hydraulically operated

(2) Open to let gear down, then close to improve lateral stability in the landing configuration

(3) Retracted to near-closed position (3-5 degrees from full closed) by electromechanical actuator when EMER GEAR handle is pulled, and nose gear clears gear doors

i. Strut doors--two

(1) Mechanically operated by landing gear

(2) Remain open when gear extended

j. Drag brace fairing

(1) Mechanically operated by landing gear

(2) Remains open when gear extended

B. Controls and indicators

1. LDG GEAR handle

a. Location: left forward console, both cockpits

b. Purpose: UP raises gear, DN lowers gear

c. Detented: Pull to Release

2. Landing gear handle red warning light

a. Location: integral to gear handle, left console, both cockpits

b. Purpose: illuminates when

(1) One of the gear differs from the handle position

(2) One of the landing gear is not locked down with the gear handle “down”

(3) All landing gear doors are not latched closed with the gear handle “up”

Sg 1, fr 8
Fig 5: *Landing Gear Controls and Indicators*

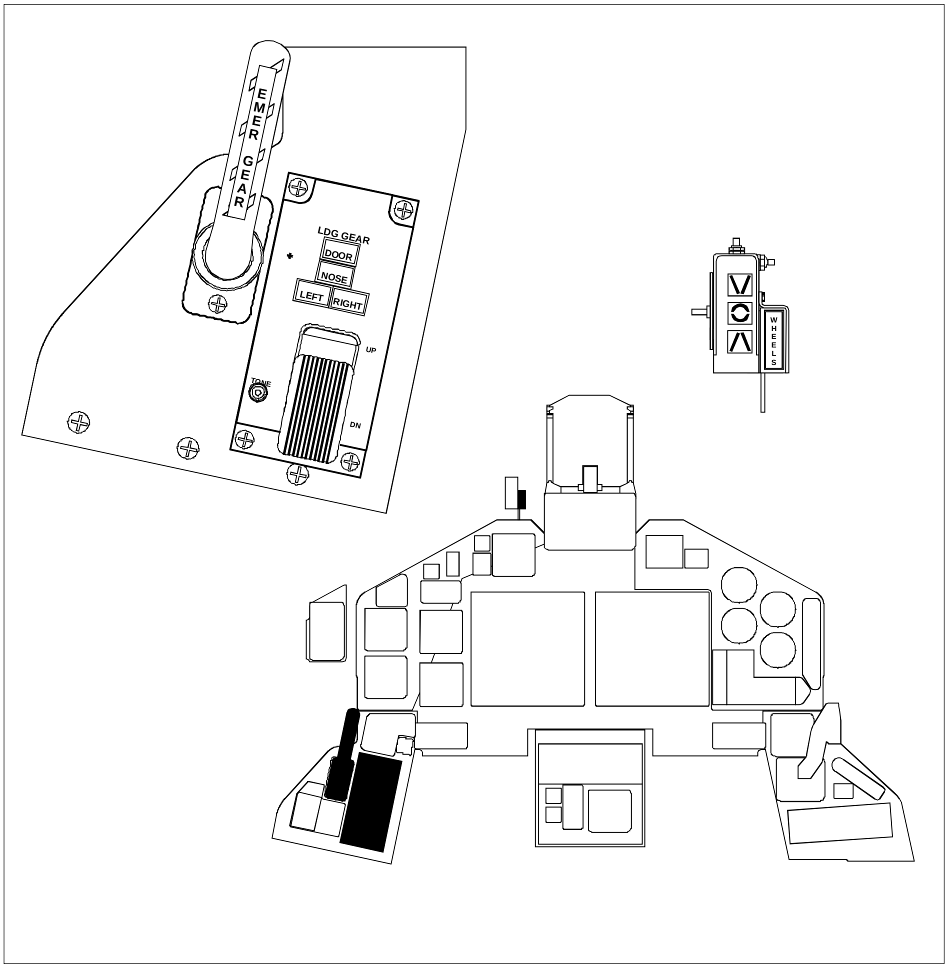


Figure 5: LANDING GEAR CONTROLS AND INDICATORS

3. EMER GEAR handle

   a. Location: left forward console, both cockpits

   b. Purpose: rotated clockwise and pulled, it unlocks gear/doors and activates emergency gear extension

      NOTE: Gear may be lowered but not raised with the emergency gear handle. Even though activating the EMER GEAR handle will allow the gear to free-fall, it may be necessary to apply slight g loads and yaw on the aircraft to lock the gear in position.

4. LDG GEAR position indicator

   a. Location: left instrument panel, both cockpits

   b. Purpose: green lights illuminated when left-hand (LEFT), right-hand (RIGHT), and nose (NOSE) gear are down and locked

      NOTE: The three individual gear-down-and-locked lights are active whether emergency or normal gear extension is used.

5. LDG GEAR DOOR indicator light

   a. Location: left instrument panel, both cockpits

   b. Purpose: amber light illuminated when any gear door is not closed and locked during either gear-up or gear-down cycles

6. WHEELS warning light

   a. Location: right of AOA indexer, both cockpits

   b. Purpose: red light illuminates flashing and the wheels warning tone pulses on and off every 200 milliseconds when:

      (1) LDG GEAR handle is not set to DN, the throttle is below 95% N_2 rpm and either of the following exist

         (a) Altitude is less than 7,200 ft MSL (may occur as high as 9,800 ft) and the airspeed is less than 170 knots

         (b) The FLAPS/SLATS levers are not in the UP position

7. TONE button

   a. Location: left of LDG GEAR UP/DN handle, both cockpits

Sg 1, fr 9
Fig 6: *NLG Strut Pressure Gauges*

b. Purpose: silences landing gear warning tone

8. Strut high pressure gauge

   a. Location: nose wheel shock strut

   b. Purpose: displays nitrogen pressure in high-pressure section of nose strut

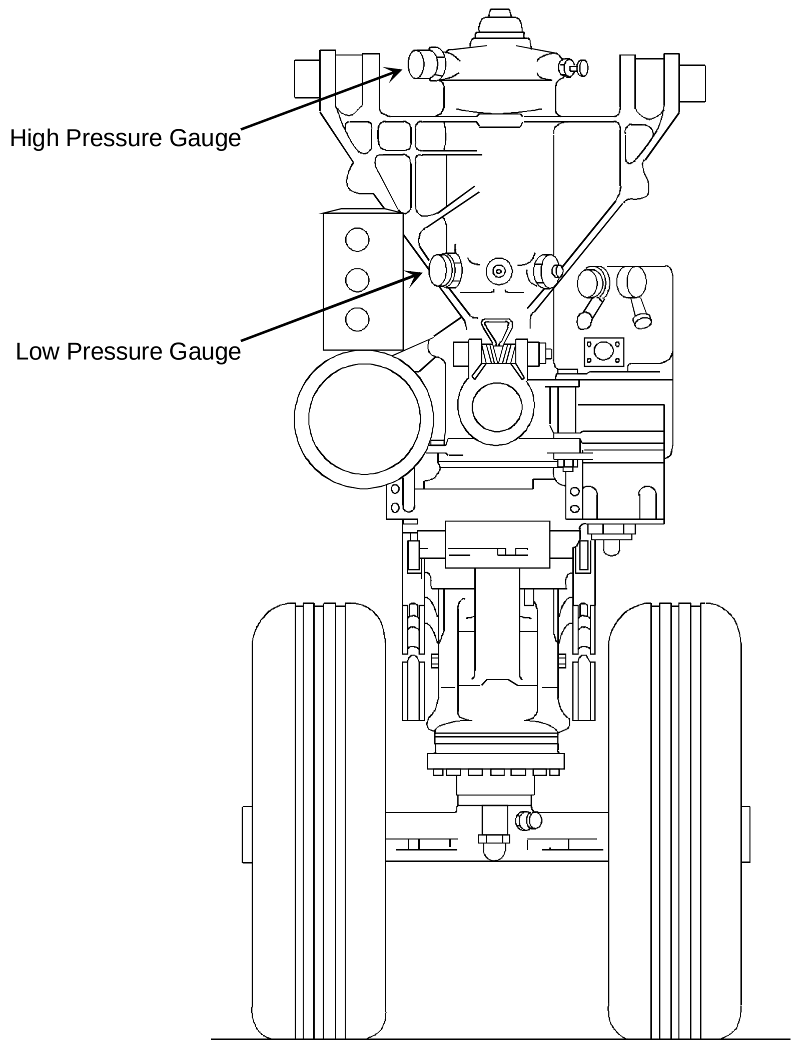


Figure 6: NLG STRUT PRESSURE GAUGES

Sg 1, fr 10 (Video)
Fig 7: *NLG Strut Inflation Chart*

9. Strut low pressure gauge

   a. Location: nose wheel shock strut

b. Purpose: displays nitrogen pressure in low-pressure section of nose strut

NOTE: Nose strut high and low pressure gauges, pressure must be in accordance with placard of inflation pressures.

NOTE: Wheel strut piston should reveal approximately 3.25 inches exposed chrome.

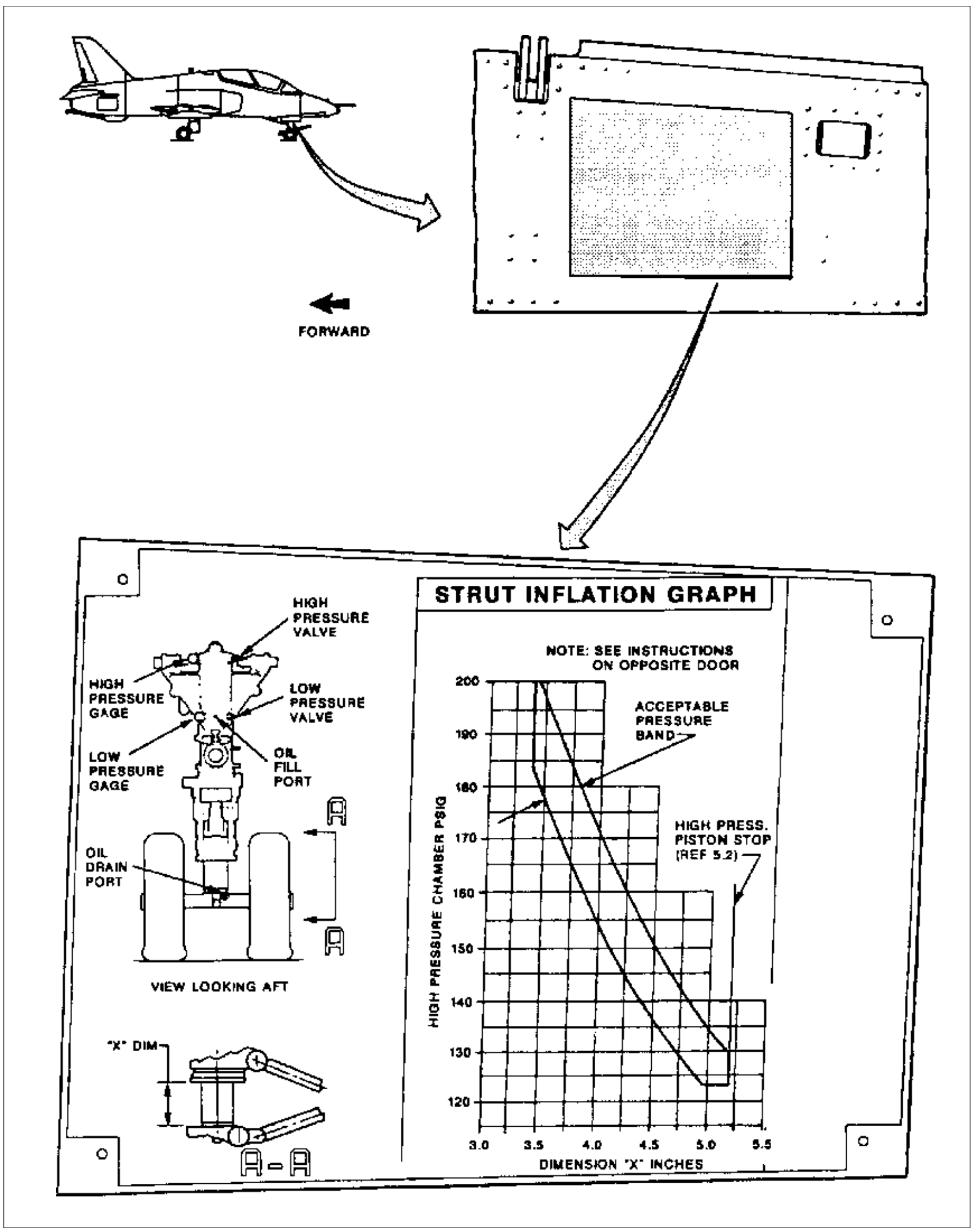


Figure 7: NLG STRUT INFLATION CHART

Fig 8: Landing Gear Indications

C. Operation

LESSON NOTES

Refer to Figure 8 throughout the discussion on the operation of the landing gear systems.

POSITION			LIGHT		
CONTROL HANDLE	LANDING GEAR	DOOR	NOSE, LEFT, RIGHT	DOOR	CONTROL HANDLE
Down	Down and Locked	Closed	Green	Off	Off
Up	Down and Locked	Closed	Green	Off	Red
Up	Down and Locked	Any Open	Green	On	Red
Up	Not Down and Locked	Open	Off	On	Red
Up	Up and Locked	Open	Off	On	Red
Up	Up and Locked	All Closed	Off	Off	Off
Down	Not Down and Locked	All Closed	Off	Off	Red
Down	Not Down and Locked	Any Open	Off	On	Red
Down	Down and Locked	Any Open	Green	On	Off

NOTE: The emergency landing gear handle does not affect the indication logic. The lights will operate as above when the landing gear moves.

Figure 8: LANDING GEAR INDICATIONS

1. Both NLG and MLG are electrically controlled and hydraulically operated

2. Powered by 3000 psi pressure from HYD 1

Sg 1, fr 11 **Video:** *Landing Gear Sequence*

   a. Sequence of normal main gear/door extension

      NOTE: Extension and retraction commence concurrently; however, all three gear/door assemblies have their own hydraulic actuators and do not necessarily complete the extend/ retract cycle at exactly the same time (although they are within a few seconds of each other).

(1) Setting LDG GEAR UP/DN handle to DN electrically initiates operation of landing gear hydraulic control valve

(2) Hydraulic pressure is directed to open inner (main gear) doors (in approximately 1 second)

(3) When inner (main gear) doors fully open, gear uplocks are hydraulically released, and hydraulic extension actuator is activated

(4) When fully extended, gear is hydraulically and mechanically downlocked by hydraulic downlock actuator and springs acting on lock links attached to side brace

(5) After gear is down and locked, inner doors close and lock hydraulically

NOTE: The trunnion, trailing arm, and fixed strut doors remain open because they are mechanically attached to the gear.

b. Sequence of nose gear/door extension

Sg 1, fr 13
Video: *Landing Gear Extend Sequence*

(1) Placing LDG GEAR UP/DN handle to DN electrically initiates operation of landing gear hydraulic control valve

(2) Hydraulic pressure is directed to open forward doors (in approximately 1 second)

(3) When gear doors fully open, gear uplocks are hydraulically released, and hydraulic extension actuator is activated

(4) When fully extended, gear is mechanically downlocked by ring on drag brace

(5) After gear is down and locked, forward nose gear doors close and lock hydraulically

Sg 1, fr 15
Video: *Landing Gear Retract Sequence*

NOTE: Strut doors and the drag brace fairing remain open because they are mechanically linked to the gear.

NOTE: The total time for MLG/NLG extension is about 15 seconds.

c. Sequence of main gear/door retraction

NOTE: If the LDG GEAR handle is set to UP with weight on wheels, the gear will not retract.

(1) Placing LDG GEAR UP/DN handle to UP electrically initiates operation of landing gear hydraulic control valve

(2) Hydraulic pressure is directed to open inner (wheel) doors (in approximately 1 second)

(3) When gear doors fully open, downlocks are hydraulically released and hydraulic retraction actuator returns gear to <u>up</u> position

NOTE: Trunnion, trailing arm, and fixed strut doors will close as gear retracts because they are mechanically attached to the gear.

(4) When fully retracted, hydraulically operated uplocks will lock gear

(5) After gear is up and locked, inner (wheel) doors hydraulically close and lock

d. Sequence of nose gear/door retraction

(1) Placing LDG GEAR UP/DN handle to UP electrically initiates operation of a landing gear hydraulic control valve

(2) Hydraulic pressure is directed to open nose gear doors (in approximately 1 second)

(3) When gear doors fully open, downlocks are hydraulically released and hydraulic retraction actuator returns gear to <u>up</u> position, mechanically closing drag brace fairing and strut doors as gear raises

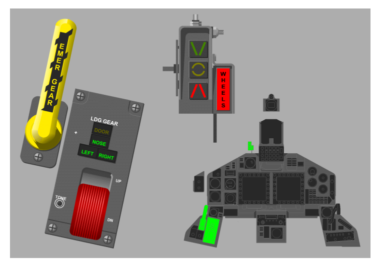
(4) When fully retracted, gear is mechanically uplocked and held up by hydraulic pressure

(5) After gear is up and locked, nose gear doors close and lock

NOTE: The total time for MLG/NLG retraction is about 10 seconds.

e. Emergency extension system

Sg 1, fr 16
Landing Gear Controls and Indicators



(1) Mechanically controlled and gravity operated

(2) Used whenever a HYD 1 or total electrical failure occurs

(3) Operates both NLG and MLG

(4) Initiated by rotating the EMER GEAR handle clockwise and then pulling, which:

(a) Mechanically releases gear uplocks and door locks

(b) Neutralizes fluid pressure in retract and extend hydraulic lines

(c) Allows landing gear to extend by gravity free-fall

(5) Mechanical downlocks engage when fully extended

(6) MLG inner doors do not close during emergency gear extension

(7) NLG forward doors are driven to near closed position (3-5 degrees from full closed) by electromechanical actuator powered by 28 VDC essential bus when emergency gear handle is pulled and NLG clears the forward doors

CAUTION: If the landing gear is emergency extended, hydraulic pressure will not be supplied to the nose wheel steering and the system will be inoperative.

(8) Gear cannot be raised with the EMER GEAR handle

NOTE: Once down and locked, the gear cannot be retracted unless HYD 1 power returns.

NOTE: The LDG GEAR DOOR caution light will remain illuminated when the gear is lowered using the EMER GEAR handle.

(9) If electrical power is available, cockpit gear down-and-locked lights (LDG GEAR NOSE, LEFT, and RIGHT) are functional whether either normal or emergency gear extension is used. This also applies to door lights, i.e., doors will not retract (close) and light stays on

D. Limitations

1. Maximum airspeed for lowering gear and flying with gear extended: 200 KIAS

2. Landing gear retract command is disabled unless nose strut extended and nose wheel centered

   a. Strut extension normally centers nose wheels mechanically with centering cams

   b. Nose wheel steering (NWS) automatically centers nose wheel if cams fail to do so

E. Summary:

The landing gear system is electrically controlled, hydraulically operated, and mechanically locked in either the up or down position. It is comprised of the left and right main landing gear (MLG) and the nose landing gear (NLG). The landing gear system is designed to absorb the shock of carrier landings.

Cockpit controls and indicators used to operate the landing gear system include the LDG GEAR UP/DN handle, the landing gear handle warning (red) light, the EMER GEAR handle, the LDG GEAR LEFT, RIGHT, and NOSE lights, the LDG GEAR DOOR light, the WHEELS warning light, and the TONE button.

Maximum airspeed for lowering the gear and flying with the gear extended is 200 KIAS and the landing gear retract command is disabled unless the nose strut is extended and the nose wheel is centered.

PROGRESS CHECK

Question 1 — 1.5.4.1.1.1
How is the landing gear system controlled and operated and what is the maximum allowable airspeed for flying with the gear extended?

ANSWER: The landing gear is electrically controlled and hydraulically operated and the maximum airspeed for flying with the gear extended is 200 KIAS.

Sg 2, fr 2
Lesson Organization

HYDRAULIC SUBSYSTEMS

* Landing gear system
* **Landing gear-related components**
* Aircraft interfaces

Sg 2, fr 3
Fig 9: *Hydraulic System Block Diagram*

II. Landing gear-related hydraulic components

A. Brakes/anti-skid

1. Major components **1.4.10.3.1**, **1.4.11.3.1**

a. Master cylinder: converts foot pressure into hydraulic pressure that controls brake control valve

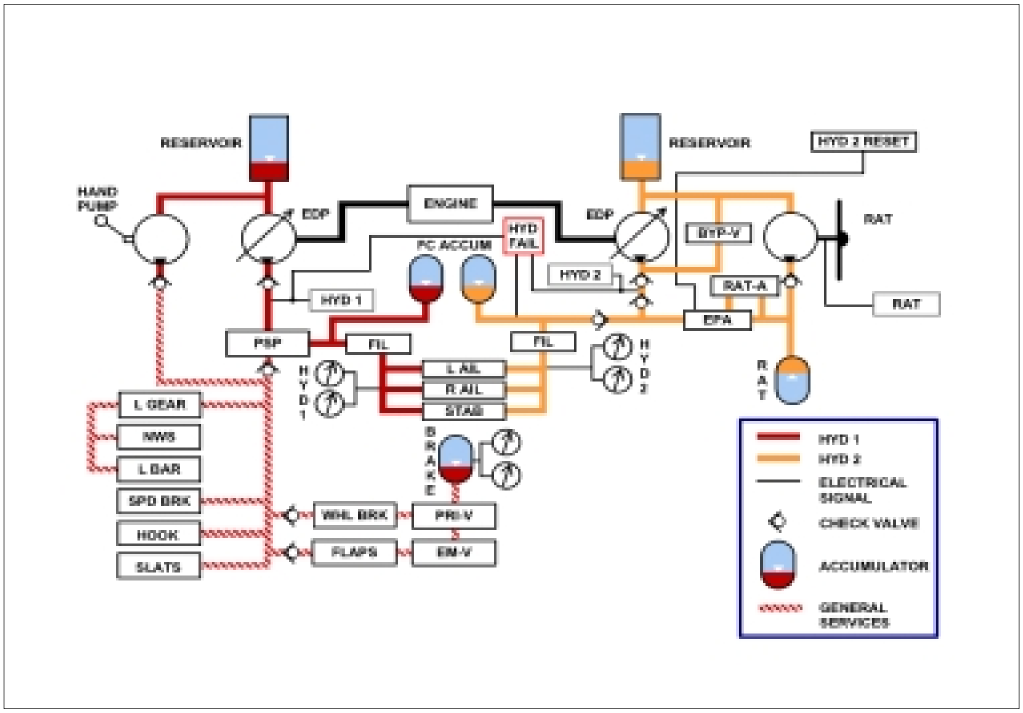


Figure 9: HYDRAULIC SYSTEM BLOCK DIAGRAM

Sg 2, fr 4
Fig 10: *Wheel Brake/ Anti-Skid System Block Diagram*

b. Brake control valve: supplies HYD 1 hydraulic pressure to operate wheel brakes whenever the brake pedals are depressed, the parking brake is engaged, or upon command from the de-spin actuator

c. Anti-skid control valve: when a rapid wheel decel is sensed, routes HYD 1 hydraulic pressure to system return to prevent a tire skid

d. Brake unit: transmits HYD 1 hydraulic pressure into mechanical energy required to stop rotation of main gear wheels

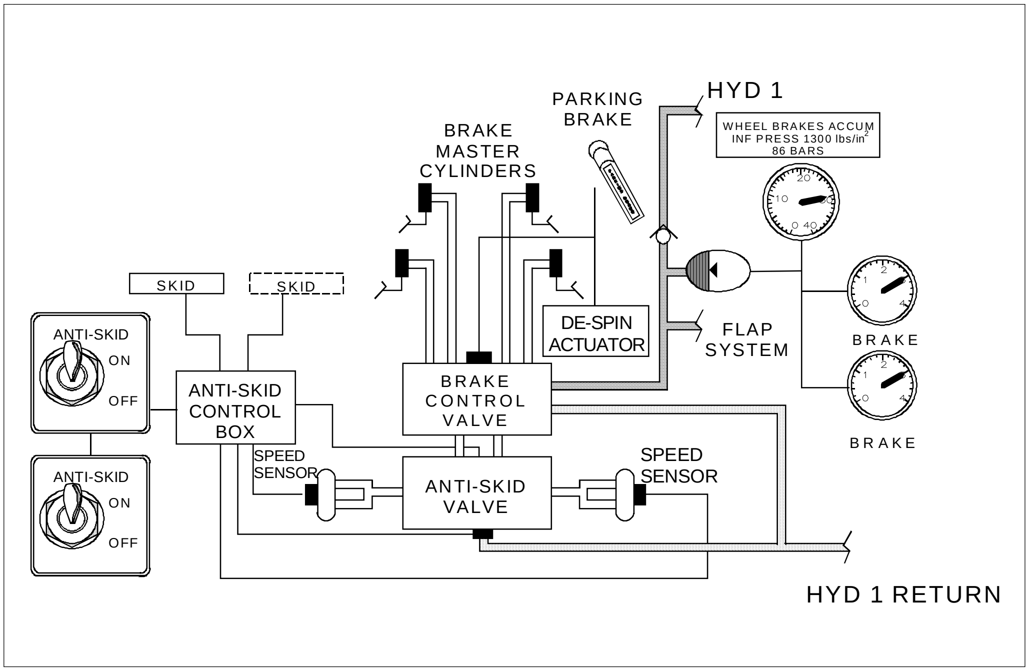


Figure 10: WHEEL BRAKE/ANTI-SKID SYSTEM BLOCK DIAGRAM

e. De-spin actuator: signals brake control valve to apply hydraulic power to brake units to stop wheel rotation when gear is raised

f. Parking brake: mechanically operates brake control valve to apply hydraulic pressure simultaneously to both wheel brake units to park aircraft

g. Anti-skid control box: "brains" of anti-skid system; controls operation of anti-skid valve

h. Speed sensors: measure rotation speed of each wheel; resulting signal sent to anti-skid control box and used to predict when a wheel is about to skid

2. Controls and indicators **1.4.10.3**, **1.4.11.3**

a. Brake pedals

(1) Location: top of each rudder pedal, both cockpits

(2) Purpose: connected to master cylinder, used to operate brake control valve which in turn routes braking pressure to each wheel

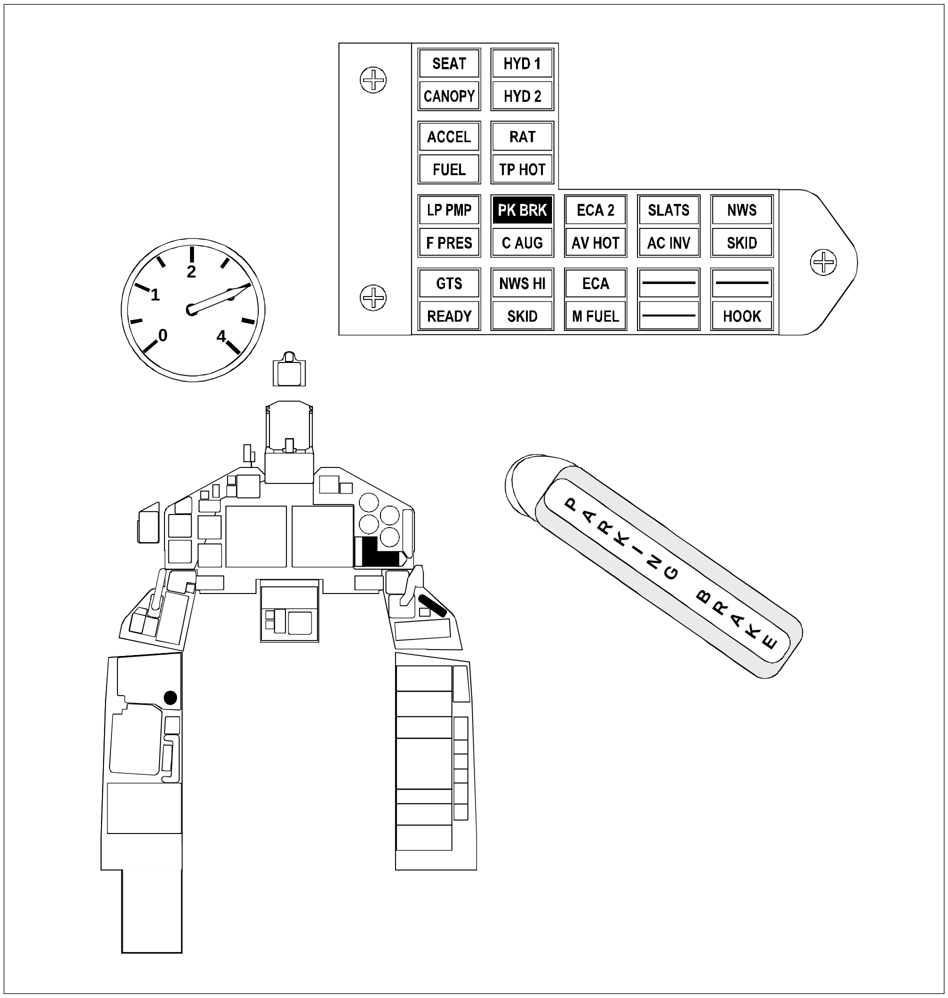


Figure 11: BRAKE SYSTEM CONTROLS AND INDICATORS

Sg 2, fr 5
Fig 11: *Brake System Controls and Indicators*

b. BRAKE pressure gauge

(1) Location: left console, both cockpits

(2) Purpose: displays nitrogen pressure in wheel brake/emergency flap accumulator (same as wheel brake/emergency flap accumulator pressure gauge in right main wheelwell)

NOTE: The wheel brake/emergency flap accumulator maintains hydraulic system pressure to the brakes and flaps if HYD 1 fails. It also maintains pressure to the parking brakes while the aircraft is on the ground. The cockpit BRAKE pressure gauge should read 3000 psi if HYD 1 is operational and a minimum of 1300 psi if HYD 1 is shut down. The gauge displays nitrogen preload pressure or HYD 1 system pressure trapped in the accumulator.

c. PK BRAKE caution light

(1) Location: caution advisory panel, both cockpits

(2) Purpose: illuminates (along with flashing MASTER ALERT light and caution tone) when parking brake handle is set to the engaged position and throttle is advanced past 70% N_2

d. PARKING BRAKE handle

(1) Location: lower right instrument panel, front cockpit only

(2) Purpose

(a) Pulled out and turned clockwise--sets parking brake

(b) Turned counterclockwise and pushed in--releases parking brake

e. Wheel brake/emergency flap accumulator pressure gauge

(1) Location: right main wheelwell

(2) Purpose

Sg 2, fr 6
Fig 12: *Wheel Brake/ Emergency Flap Accumulator Pressure Gauge*

(a) Indicates pressure in wheel brake/ emergency flap accumulator when engine not running (cockpit BRAKE pressure gauge indicates same pressure)

(b) Gauge calibrated from 0 to 4000 psi in 100-psi increments and labeled every 1000 psi

(c) When hydraulic fluid supply depleted from accumulator, gauge displays nitrogen pressure only

(d) Should indicate a minimum of 1300 psi during preflight checks

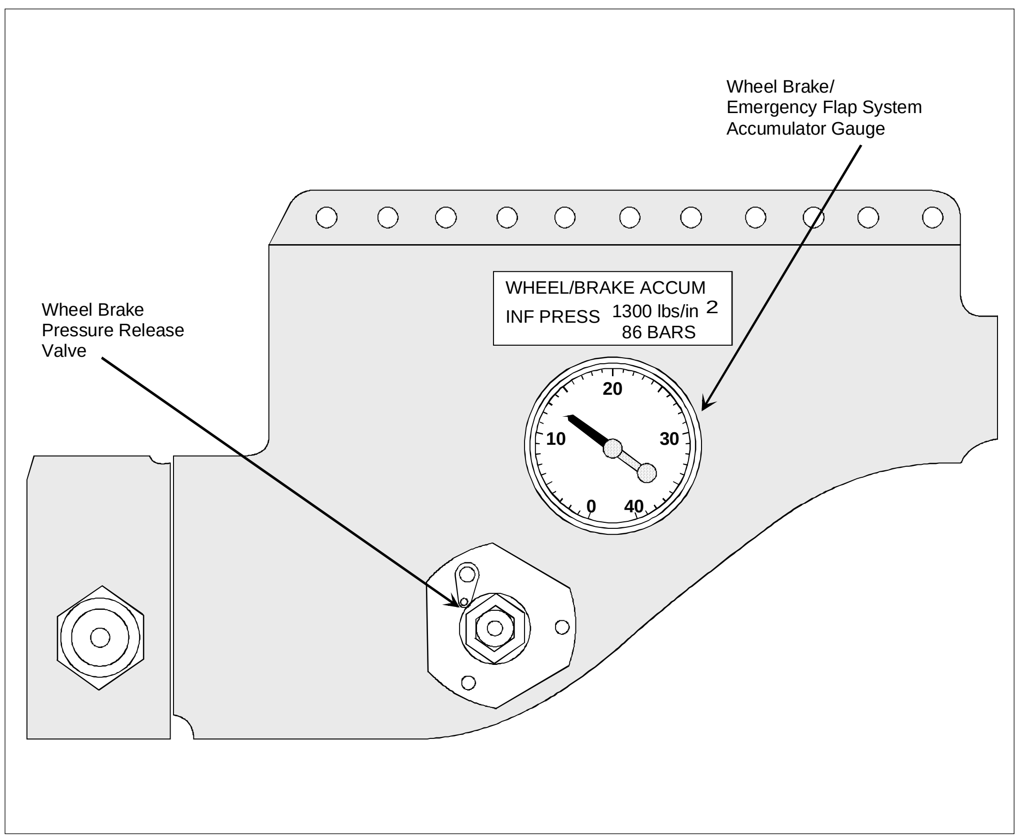


Figure 12: WHEEL BRAKE/EMERGENCY FLAP ACCUMULATOR PRESSURE GAUGE

f. ANTI-SKID switch

(1) Location: left console, both cockpits

(2) Purpose

(a) Enables operation of anti-skid system

(b) To function, switch must be set to ON in both cockpits

(c) Resets anti-skid control if no malfunction within system

g. SKID caution light

(1) Location: caution advisory panel, both cockpits

(2) Purpose: illuminates when

(a) Failure condition has been detected by anti-skid control box; accompanied by flashing MASTER ALERT and caution tone

h. SKID advisory light

(1) Location: caution advisory panel, both cockpits

(2) Purpose: illuminates in both cockpits when anti-skid is selected and landing gear are down and locked

Sg 2, fr 7
Fig 13: *Anti-Skid System Controls and Indicators*

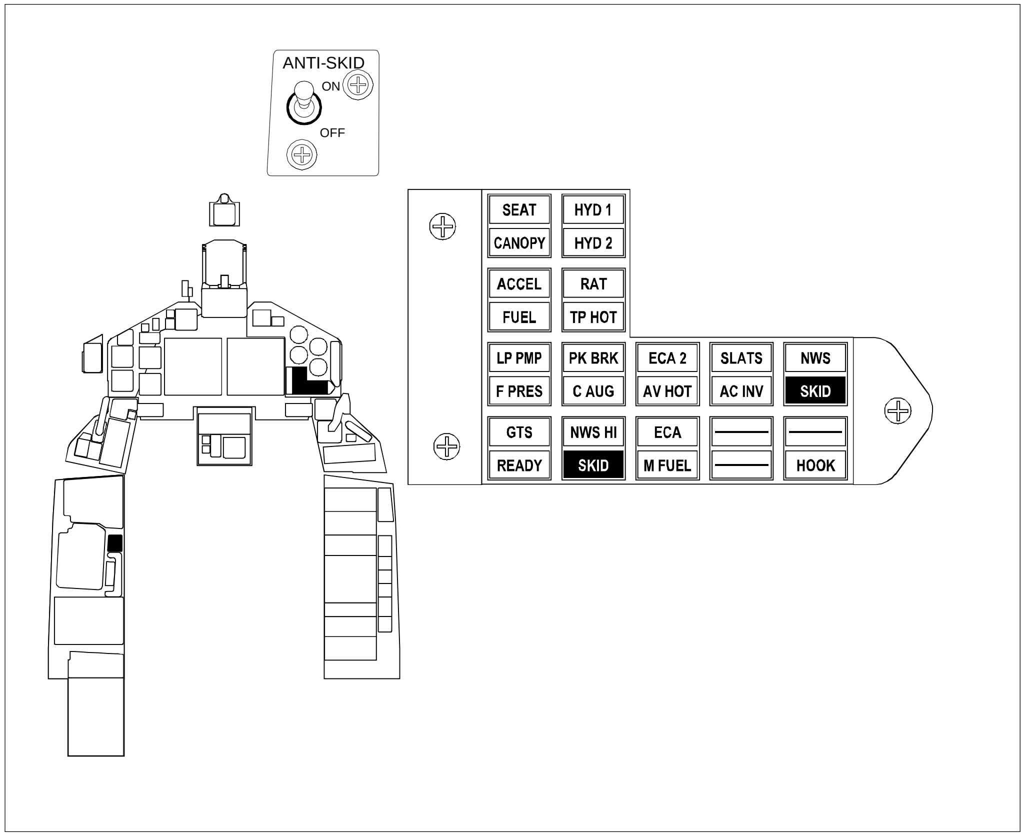
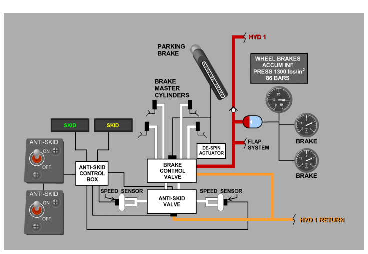


Figure 13: ANTI-SKID SYSTEM CONTROLS AND INDICATORS

Sg 2, fr 8
Wheel Brake/Anti-Skid System Block Diagram



3. Operating characteristics **1.4.10.2.1**, **1.4.11.2.1**

   a. Applying pressure to rudder pedal-mounted brake pedals controls operation of brake master cylinders

      NOTE: There is a master cylinder for each brake pedal (two in the front cockpit and two in the aft cockpit).

   b. Hydraulic fluid from master cylinders controls operation of brake control valve

      NOTE: As a brake pedal is pressed, the pressure from the master cylinder opens the brake control valve, allowing more of HYD 1 (3000 psi) pressure to be applied to the associated wheel brake unit.

Sg 2, fr 9
Fig 14: *Brake Unit Inspection*

c. Wheel brake wear indicators

(1) Parking brake must be set

(2) Brake wear indicators (two per wheel) must protrude beyond bottom of recess in brake housing

(3) Unacceptable condition is indicated by flush or recessed indicators

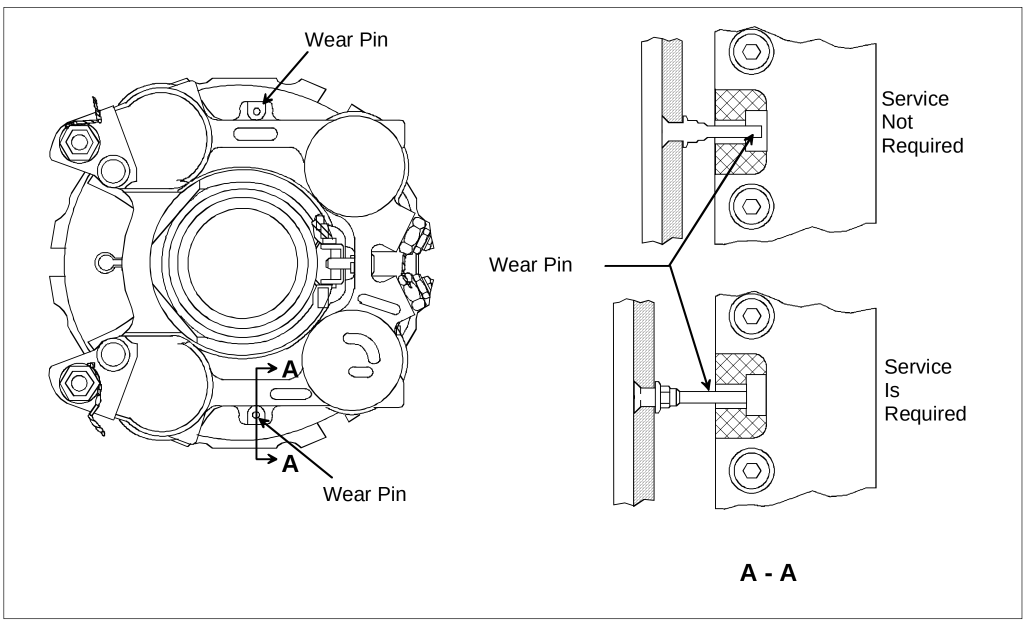
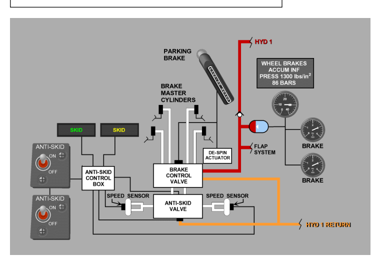


Figure 14: BRAKE UNIT INSPECTION

Sg 2, fr 10
Wheel Brake/Anti-Skid System Block Diagram



d. With both ANTI-SKID switches ON, hydraulic pressure from brake control valve is regulated by anti-skid valve which is controlled by anti-skid control box

(1) Speed sensors on both wheels send relative rotation speed to anti-skid control box

(2) When speed sensor senses an impending skid, the anti-skid control box signals anti-skid valve to reduce brake pressure on both wheels. As wheel rotational speed recovers, brake pressure is reapplied to a level just below that which caused the skid.

(3) Following a HYD 1 failure, wheel brake/ emergency flap accumulator stores enough hydraulic pressure for at least 10 brake applications after an emergency flap extension

NOTE: Because the anti-skid valve dumps hydraulic pressure to HYD 1 return, anti-skid must be de-selected when HYD 1 fails and the wheel brake/emergency flap accumulator is supplying all braking pressure. Anti-skid will rapidly deplete accumulator pressure, possibly not leaving enough residual pressure to brake the aircraft safely.

e. Anti-skid system touchdown protection: if pilot has pressure on brake pedals before weight on wheels, anti-skid system dumps all brake pressure to system return to prevent locked wheels (with resulting blown tires) upon touchdown

f. Operating parking brake handle mechanically opens brake control valve, routing system (or accumulator) pressure simultaneously to both brake units

NOTE: After engine shutdown, the ANTI-SKID switch must be set to OFF before setting the parking brake. If anti-skid is left on and the battery switches are turned on, pressure to the parking brake may bleed off over a period of time.

g. Brake control valve is mechanically opened by de-spin actuator when wheels-up is selected, applying hydraulic pressure to wheel brake units to stop wheel from spinning prior to retracting gear

h. Differential braking may be used to steer aircraft if NWS is inoperative or de-selected

4. Limitations

   a. During acceleration at aircraft ground speeds less than 30 knots, the system is not active, and only manual braking is available

   b. During deceleration, anti-skid is not operational below 10-13 knots ground speed to allow for directional braking during aircraft taxi

   c. If anti-skid dumps all pressure for more than 2 seconds or no wheel spin up detected for 3 seconds after touchdown, anti-skid system shuts down and SKID caution light comes on--after 1 second delay, system reverts to manual braking

      NOTE: Anti-skid may be reset by cycling ANTI-SKID switch in either cockpit.

PROGRESS CHECK

Question 2 — 1.4.10.2.1
What should the BRAKE pressure gauge indicate when the wheel brake/emergency flap accumulator is functioning normally and HYD 1 is operating?

ANSWER: 3000 psi

5. Summary:

   The brakes/anti-skid system is designed to provide maximum effective braking power on all runway surfaces. When engaged, the anti-skid system regulates brake pressure. Speed sensors continuously monitor the rate at which the wheels are spinning down. If one wheel is spinning down more rapidly than the other (skid starting), the anti-skid system acts by dumping pressure to both wheel brakes until both wheels are again spinning at the same rate.

HYD 1 produces the hydraulic pressure used by the brakes/anti-skid system. If HYD 1 fails, operation of the brake system depends on the wheel brake/ emergency flap accumulator for hydraulic pressure, in which case the anti-skid system must be set to OFF or it will rapidly deplete the hydraulic pressure maintained in the wheel brake/emergency flap accumulator. Cockpit controls and indicators used to operate the brakes/anti-skid system include the brake pedals, the BRAKE (wheel brake/emergency flap accumulator) pressure gauge, the PK BRK caution light, the PARKING BRAKE handle, the ANTI-SKID switch, the SKID caution light, the SKID advisory light. An additional wheel brake/ emergency flap accumulator pressure gauge is located in the right main wheelwell on the exterior of the aircraft.

B. Brake Pressure Release System [AFC 256, PT2]

1. Major components

a. Components added include an additional launch bar proximity switch, a BRK PRESS caution light, and an anti-skid control box modification (EMI filters)

b. Pre-existing aircraft components used by the system include the 95% throttle position proximity switch, the right and left main landing gear down and locked proximity switches, launch bar proximity switch, anti-skid valve, parking brake handle proximity switch, and NWS button

c. Brake pressure release system designed to release brake pressure through existing anti-skid valve, independent of anti-skid control box

2. Controls and indicators

a. System commanded brake release is automatically provided when a combination of specific conditions are met. The system engages when it detects LDG GEAR down and locked and launch bar EXTENDED with LAUNCH BAR switch in the RETRACT position. Once engaged, the system then monitors 95% throttle position, LDG GEAR down and locked condition, NWS button relays, and parking brake handle position to determine normal brake operation or system commanded brake release

b. BRK PRESS caution light

(1) Location: caution/advisory panel, both cockpits, added to advisory panel just above the HOOK warning light

(2) Purpose: indicates a system failure or indicator circuit failure

3. Operating characteristics

a. Electrically controlled (28 VDC essential bus)

b. The brake pressure release during catapult launch modification was incorporated to prevent main mount tire(s) blow out due to inadvertent brake pressure being applied to the brake pedal(s) during catapult launch. The brake pressure release system is activated with:

(1) The LDG GEAR down and locked (proximity switch relay-right main LG)

(2) The launch bar down and locked in the shuttle, with the LAUNCH BAR switch selected to RETRACT (up position)

(3) Throttle position greater than 95%

(4) Nose wheel steering button NOT pressed

(5) Parking brake handle in (OFF)

These conditions are met only when the aircraft is locked in the shuttle and ready for launch.

Brake pressure is returned two (2) seconds after the launch bar position switch senses that the launch bar is in the UP position. Reducing the throttle below 95% will restore brake pressure immediately. Although not recommended, pulling the parking brake handle out/or pressing and holding the NWS (high-gain) button will also restore brake pressure immediately

NOTE: A failure of a component of the brake pressure release system will NOT result in damage or failure of any component of the brake or anti-skid systems. With the throttle below 95%, there is no single point failure that will result in the loss of brakes during field or carrier landing, field or carrier taxi, or field takeoff.

NOTE: Activation of the parking brake handle deactivates the brake pressure release system by removing electrical power, deactivating the release circuit, and applying parking brake pressure simultaneously. If the anti-skid system is selected ON it will operate normally with parking brake application.

c. The BRK PRESS caution light illuminates when there is a failure in the brake pressure release system, i.e., brake pressure is available. The light may also illuminate in flight with the landing gear UP due to a single component failure. However, if the BRK PRESS light illuminates due to indicator circuit failure, the brake system is functioning normally, i.e., brake pressure is available. A loss of brake pressure could only result from a simultaneous failure of more than one component. An unlikely probability, this makes the risk acceptably low. Most likely brake pressure WILL be available and a normal approach and landing can be anticipated. Also, a momentary illumination MAY OCCUR when the launch bar transitions to the RETRACT position following catapult launch, during non-catapult operation (line check), or during landing gear extension. Assume normal braking is available if the light exstinguishes after the transition period

NOTE: If the BRK PRESS caution light illuminates on the catapult with all prelaunch conditions met, i.e., aircraft in tension, throttle above 95%, LAUNCH BAR switch selected to RETRACT, NWS button NOT depressed, parking brake handle in (OFF) - SUSPEND THE CATAPULT AND ABORT THE LAUNCH!

4. Limitations:

During normal carrier and field operations, the BRK PRESS caution light should not be illuminated. The light should only illuminate when indicating a system or indicator circuit failure. If the light illuminates with all prelaunch conditions met - SUSPEND THE CATAPULT

5. Summary:

The brake pressure release system was devised with the purpose of preventing the possibility of tire blowout during catapult launch and then dealing with the emergency arresting landing scenario resulting from that blown tire. Remember that "no lights" is what to look for prior to launch. All prelaunch conditions must be met in order for the brake pressure to release.

C. Nose wheel steering (NWS)

Sg 2, fr 11
Fig 15: *Nose Wheel Steering (NWS) System Major Components*

1. Major components **1.4.9.3.1**

a. Steering motor: hydraulically powered by HYD 1 system, mechanically moves nose wheel

b. Gearbox (gear train): mechanically transmits steering motor movement to nose wheel

c. Electronic control box

(1) "Brains" of NWS; integrates signals from landing gear selection, cockpit controls, and WOW (weight-on-wheels) circuitry to control NWS

(2) Controls operation of steering motor

d. Steering collar: support bearing between fixed strut and moveable nose wheel

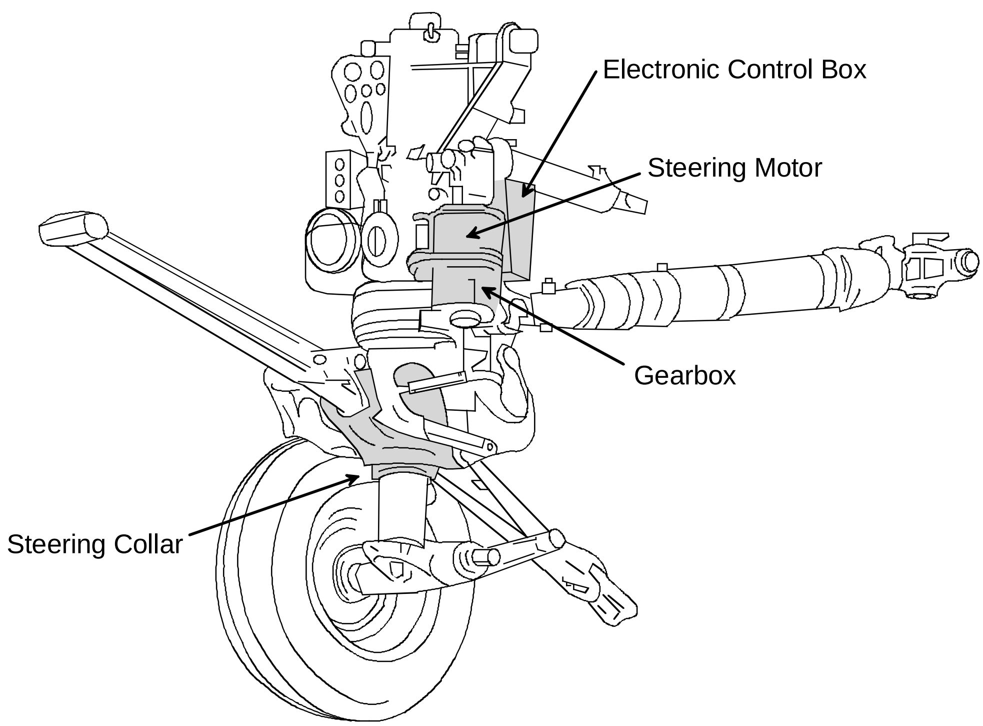


Figure 15: NOSE WHEEL STEERING (NWS) SYSTEM MAJOR COMPONENTS

Sg 2, fr 12
Fig 16: *NWS System Controls and Indicators*

2. Controls and indicators **1.4.9.3**

a. Paddle switch

(1) Location: front side at base of stick grip

(2) Purpose: momentary switch, deselects both NWS and CONTR AUG on the ground. When airborne it deselects CONTR AUG at all times and NWS as long as the gear is down

NOTE: If the control aug is deactivated, the RESET position on the CONTR AUG must be selected momentarily to regain CONTR AUG

b. NWS button

(1) Location: front side of control stick grip just above paddle switch

(2) Purpose

(a) Selects NWS high gain (+/- 65 degrees) when pressed and held

(b) Reselects NWS in low gain (+/- 12 degrees) when pressed momentarily after emergency off with paddle switch or NWS shut-down due to fault detection

(c) Selects NWS +/- 20 degrees when pressed and held while launch bar is extended

NOTE: The NWS button is nonfunctional when the aircraft is airborne.

c. NWS caution light

(1) Location: caution advisory panel, both cockpits

(2) Purpose: indicates malfunction within and subsequent shutdown of NWS system or NWS disconnected with paddle switch

d. NWS HI advisory light

(1) Location: caution advisory panel, both cockpits

(2) Purpose: on when NWS high gain selected

e. Rudder pedals: provide electromechanical directional input to NWS to control direction of aircraft

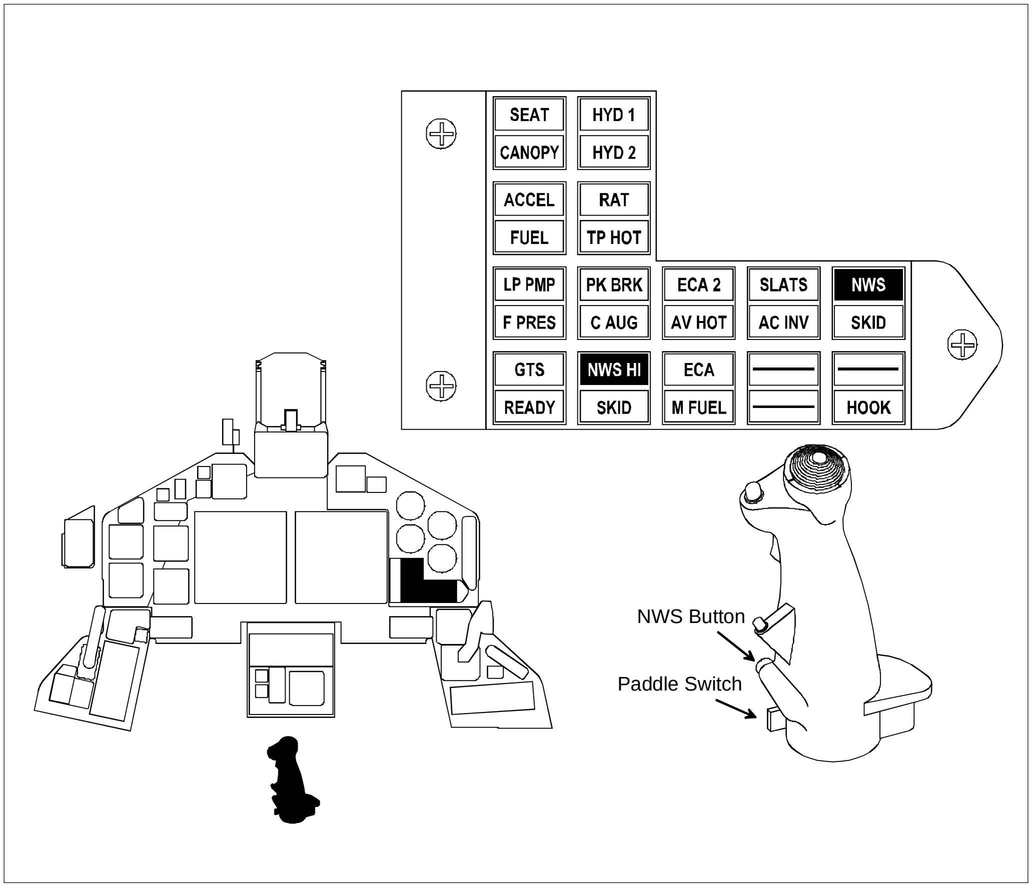


Figure 16: NWS SYSTEM CONTROLS AND INDICATORS

3. Operating characteristics **1.4.9.2.1**

a. Electrically controlled (28 VDC essential bus), hydraulically operated

b. Full time, dual gain

(1) Low gain: +/- 12 degrees nosewheel movement

(a) On and latched whenever aircraft is on deck

(b) Used for takeoff and landing

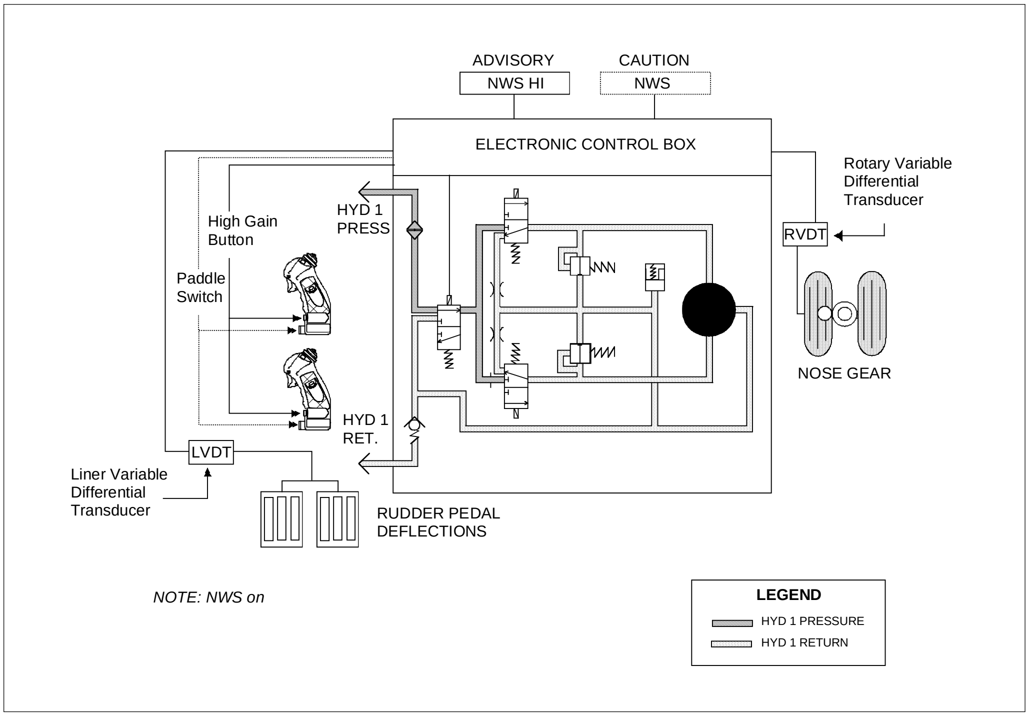


Figure 17: NWS SYSTEM COMPONENT LOCATOR

Fig 17: NWS System Component Locator

(2) High gain: +/- 65 degrees nosewheel movement

(a) Selected by pressing and holding NWS button

(b) Used for aircraft parking

NOTE: High gain nosewheel steering should be used for low speed taxi operations only, at less than 10 knots ground speed.

(3) NWS disabled when launch bar extended, +/- 20 degrees steering activated by pressing and holding NWS button

c. Nose wheel movement proportional to rudder pedal movement when on ground

d. System performs a continuous built-in test (BIT)

(1) Any detected malfunction illuminates

NWS caution light on caution advisory panel (with accompanying MASTER ALERT and caution tone)

(2) System then shuts down

e. When selected OFF or is shut down due to malfunction, system serves as hydraulic shimmy damper for free-castering nose wheel

NOTE: Use differential braking when the NWS system is inoperative.

4. Limitations

a. High gain is for aircraft parking only

b. NWS deactivated upon extension of launch bar unless NWS button pressed and held. High and low gain is not available with launch bar extended

c. Maximum speed for operating the aircraft on the runway with NWS activated is 176 KIAS

5. Summary:

The full-time, dual-gain NWS system is designed to provide adequate directional control in low gain for normal and high-crosswind landings and takeoffs while high gain provides increased nosewheel steering range for aircraft parking. The rudder pedals are used to control the nosewheels when the NWS system is engaged. If NWS is deselected or fails, differential braking can be used to steer the aircraft. The NWS system is linked to the WOW circuits and will not activate until weight-on-wheels condition exists. Lowering the launch bar deactivates the NWS, but NWS, +/- 20 degrees may be selected by pressing and holding the NWS button.

Cockpit controls and indicators used to operate the NWS system include the paddle switch, the NWS button, the NWS caution light, the NWS HI advisory light, and the rudder pedals.

D. Launch bar

Sg 2, fr 13
Fig 18: *Launch Bar System Major Components*

1. Major components **1.4.12.3.1**

a. Power unit: converts hydraulic force into mechanical energy required to extend launch bar

b. Launch bar: physically connects to carrier deck shuttle to transfer energy of catapult to aircraft during catapult launches

c. Redundant launch bar drive linkage system: dual linkage/springs provide mechanical force to

(1) Hold launch bar on deck when extended

(2) Return launch bar to up position

(3) Hold launch bar stowed when retracted

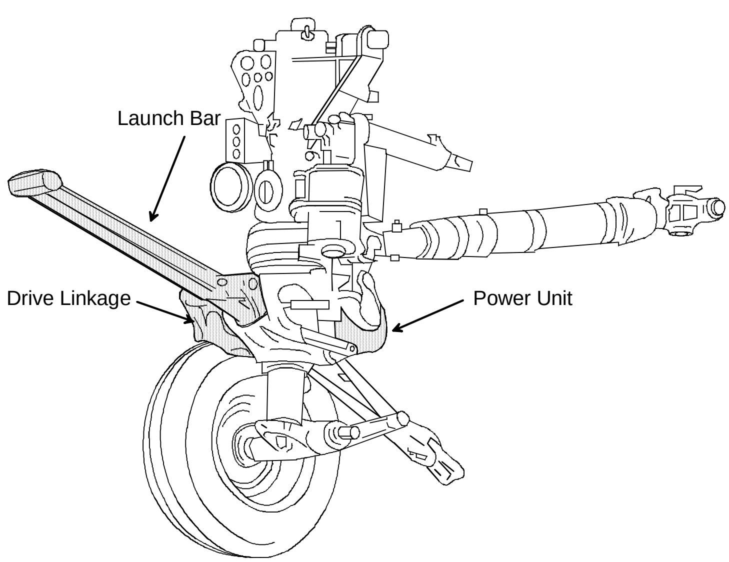


Figure 18: LAUNCH BAR SYSTEM MAJOR COMPONENTS

Sg 2, fr 14
Fig 19: *Launch Bar System Controls and Indicators (FWD Cockpit)*

2. Controls and indicators **1.4.12.3**

   a. LAUNCH BAR switch

      (1) Location: below emergency gear handle, left instrument panel, forward cockpit only

      (2) Purpose: used to extend and retract launch bar; spring-loaded to RETRACT position with weight-off-wheels

      NOTE: If the launch bar switch is left in the EXTEND position on catapult, the launch bar switch will automatically return to the retract position with weight off wheels.

   b. L BAR lights

      (1) Location: above turn & slip indicator, upper left instrument panel, both cockpits

      (2) Purpose

         (a) Green L BAR light illuminates when launch bar is extended, the LAUNCH BAR switch is set to EXTEND, and the aircraft is on the deck

         (b) Green L BAR light off when L BAR switch is set to RETRACT and launch bar held extended in shuttle mechanism

         (c) Red L BAR light illuminates (MASTER ALERT) flashes and warning tone sounds) after 10-second delay when launch bar fails to retract after launch and the landing gear is down and locked

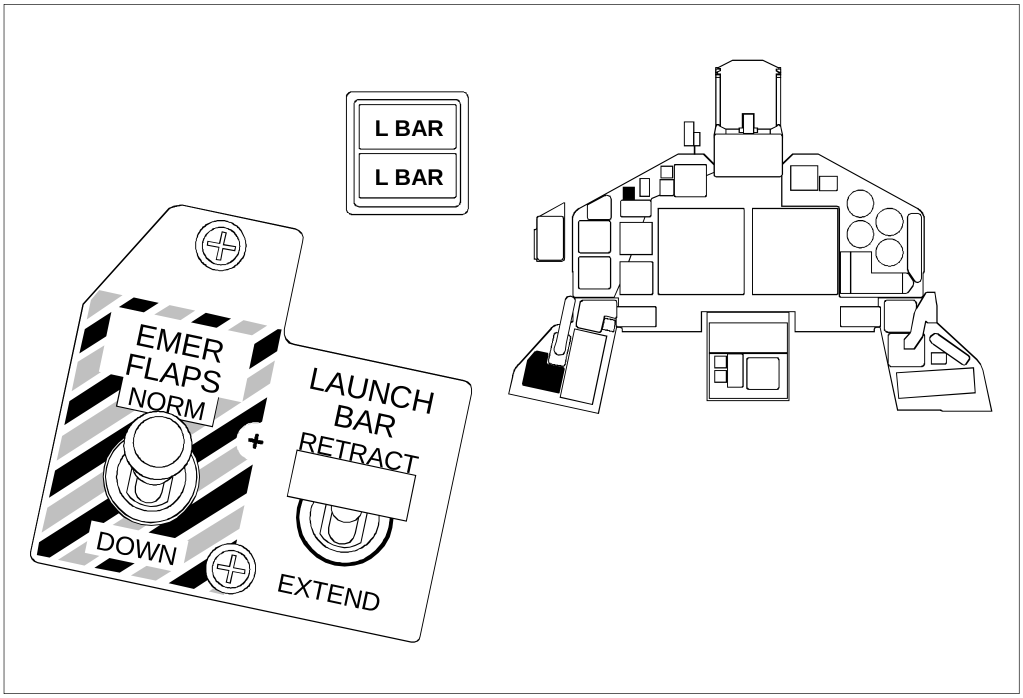


Figure 19: LAUNCH BAR SYSTEM CONTROLS AND INDICATORS (FWD COCKPIT)

3. Operating characteristics **1.4.12.2.1**

   a. Electrically controlled, hydraulically extended, mechanically retracted

   b. Spring pressure assists hydraulics in providing positive load on deck

   c. Three positions

      (1) Taxi (retracted)

      (2) Launch (extended)

      (3) Stowed (gear retracted)

   d. During catapult launch procedures, once shuttle mechanism has engaged launch bar

(1) LAUNCH BAR switch is manually selected to RETRACT and launch bar is held down by shuttle

(2) As soon as catapult stroke is complete, spring pressure retracts launch bar

4. Limitations: launch bar will not extend if nose wheel is 30 degrees or more from center

5. Summary:

The launch system consists of the launch bar, drag brace, and holdback fitting, which are integral to the NLG and are designed to secure the aircraft to the catapult mechanism and to transfer catapult energy to the aircraft during catapult launch.

The launch bar is electrically controlled, hydraulically extended, and mechanically retracted through the use of spring-loaded pressure. Three possible positions apply to the launch bar: taxi (retracted), launch (extended), and stowed (gear retracted).

Once the shuttle mechanism has engaged the launch bar during catapult launches, the LAUNCH BAR switch is set to RETRACT. Immediately after takeoff, spring pressure retracts the launch bar.

Cockpit controls and indicators used to operate the launch bar include the LAUNCH BAR switch and the L BAR lights.

E. Arresting hook

1. Major components **1.4.13.3.1**

a. Hydraulic actuator/damper

(1) Hydraulically retracts arresting hook (HYD 1 pressure, 3000 psi)

(2) Pneumatic snubber preload nitrogen pressure (with gravity assist) extends arresting hook and provides positive down-force to prevent hook bounce and possible hook slap

(3) Provides positive hydraulic retract actuator pressure to relieve mechanical load on uplatch mechanism

b. Oleo-pneumatic centering unit

(1) Buffers against lateral shock loads

(2) Spring unit keeps tail hook centered

c. Arresting hook assembly: engages deck arresting cable or field arresting gear to stop aircraft

d. Uplatch mechanism: mechanically retains arresting hook in up position

e. Arresting hook safety pin

Sg 2, fr 15
Fig 20: *Arresting Hook System Major Components*

Sg 2, fr 16
Fig 21: *Arresting Hook Inspection*

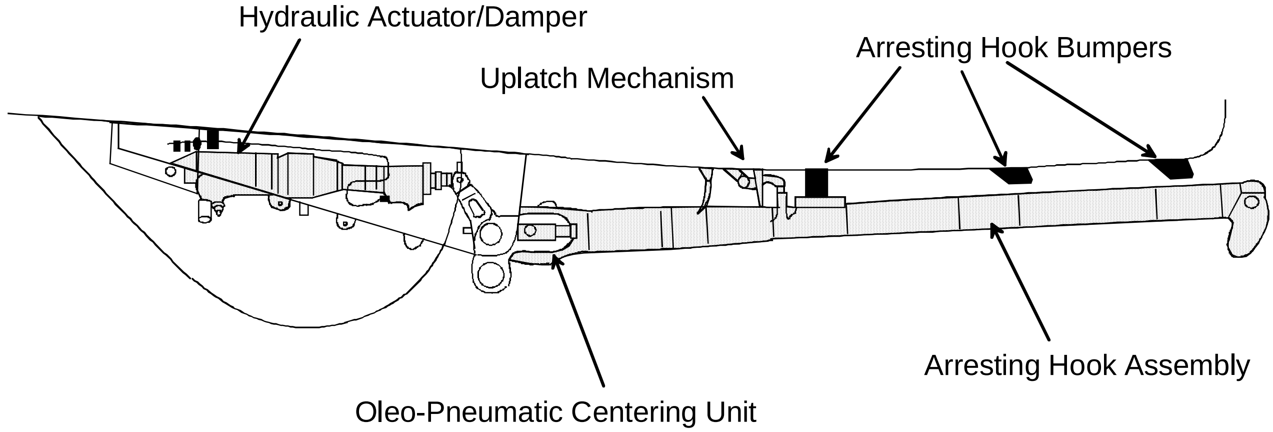


Figure 20: ARRESTING HOOK SYSTEM MAJOR COMPONENTS

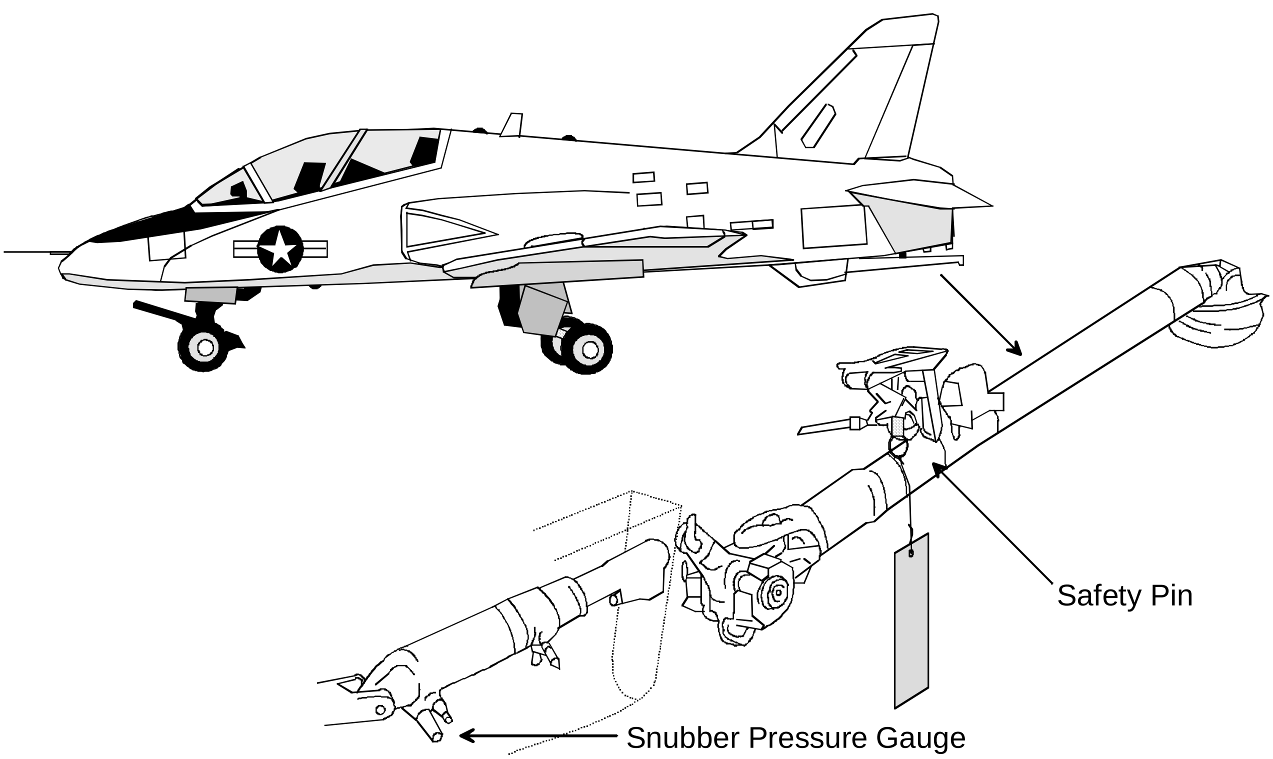


Figure 21: ARRESTING HOOK INSPECTION

2. Controls and indicators **1.4.13.3**

   a. Arresting HOOK handle

      (1) Location: right instrument panel, both cockpits

      (2) Purpose

         (a) Extends hook when pushed down

         (b) Retracts arresting hook when pulled up (handle is normally in up position)

         (c) Fore and aft handles are interconnected and move together

   b. Arresting HOOK warning light (RED)

      (1) Location: caution advisory panel, right instrument panel, both cockpits

      (2) Purpose: illuminates when selected hook position does not match actual hook position (e.g., HOOK DN selected but hook remains up)

      NOTE: The HOOK light will be on during the transition time between hook up and down.

   c. HOOK BYPASS switch

      NOTE: The HOOK BYPASS switch does not affect the operation of the arresting hook. Instead, it controls the operation and function of the AOA indexer lights and approach lights, which serve as a reminder to lower the hook during arrested landings.

      (1) Location: right instrument panel, below pitot heat switch, fwd cockpit only

      (2) Purpose

Sg 2, fr 17
Fig 22: *Arresting Hook System Controls and Indicators (FWD Cockpit)*

(a) When set to CARRIER, AOA indexer lights and approach lights flash when aircraft is in landing configuration and hook is not down

(b) When set to FIELD, above function is bypassed and lights are steady

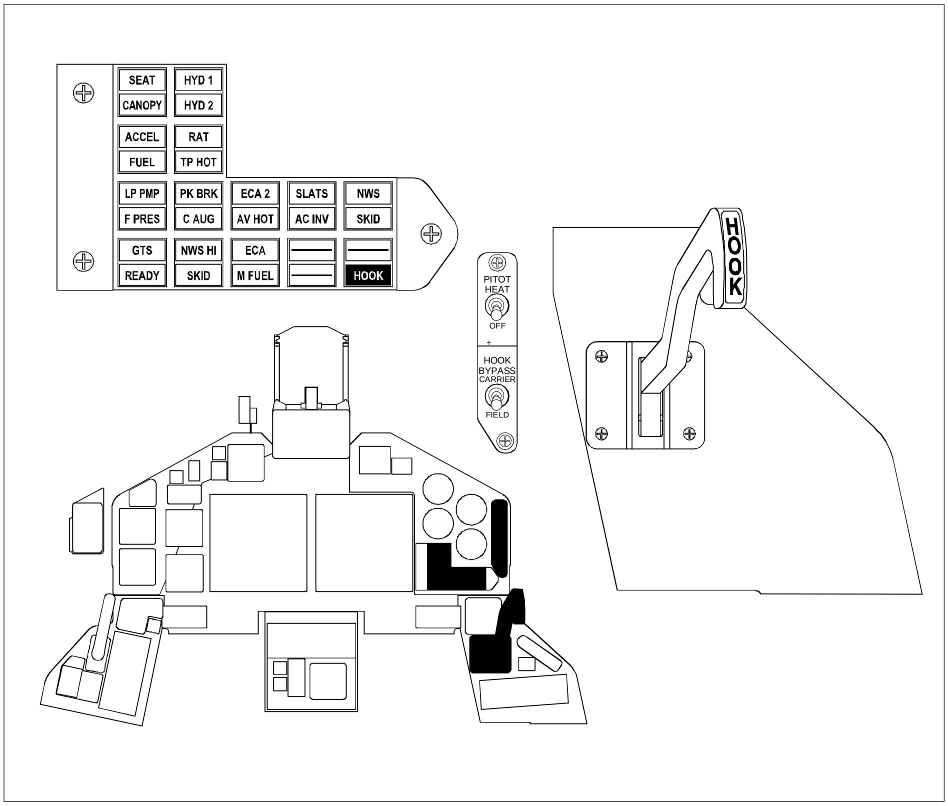


Figure 22: ARRESTING HOOK SYSTEM CONTROLS AND INDICATORS (FWD COCKPIT)

Sg 2, fr 18
Fig 23: *Arresting Hook Operation*

3. Operating characteristics **1.4.13.2.1**

   a. Setting HOOK control to DN in either cockpit mechanically controls toggle mechanism, which releases uplatch and closes selector valve that releases hydraulic pressure holding hook in up position

   b. Extends in approximately 1-1/2 seconds

   c. Extension accomplished by gravity free-fall, assisted by nitrogen pressure in actuator/ damper (hook snubber) assembly

d. Setting HOOK control to UP operates toggle mechanism that opens a selector valve and applies hydraulic pressure to actuator/damper, retracting hook

e. Retracts in approximately 6 seconds

f. Retracts hydraulically by 3000 psi pressure from HYD 1

4. Limitations: retraction of hook is not possible following HYD 1 failure

5. Summary:

The arresting hook is extended by gravity free-fall and a nitrogen charged actuator/damper. It is held in place by the actuator/damper. Hook retraction requires hydraulic power from the HYD 1 system.

Cockpit controls and indicators used to operate the arresting hook system include the arresting HOOK handle, the arresting HOOK warning light, and the HOOK BYPASS switch.

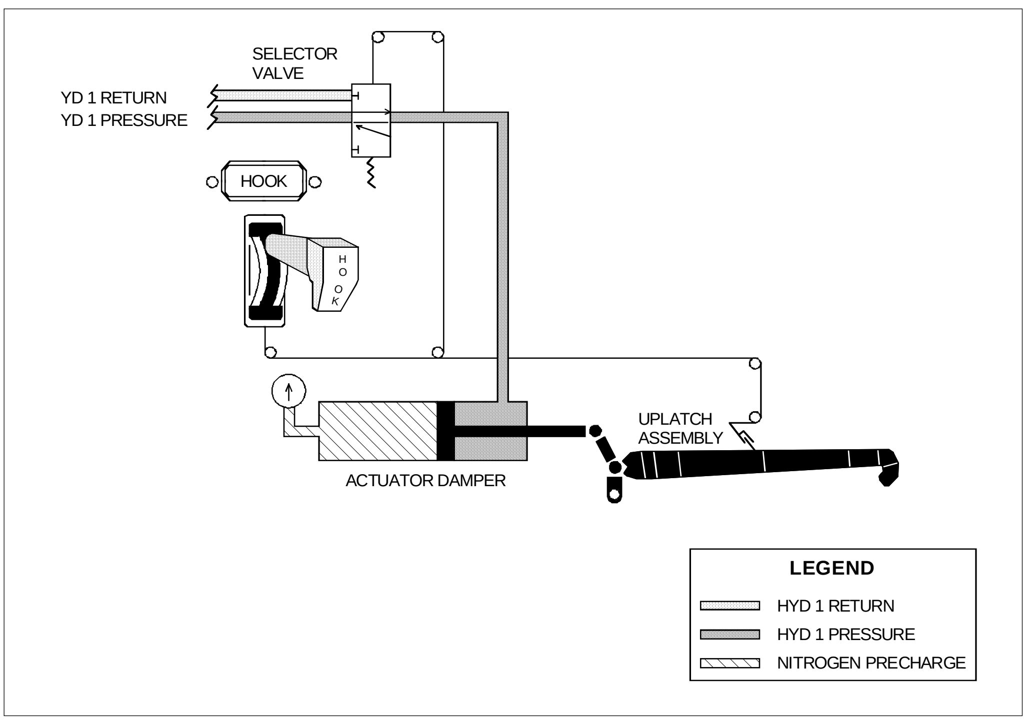


Figure 23: ARRESTING HOOK OPERATION

PROGRESS CHECK

Question 3 — 1.4.11.3
What does an illuminated SKID caution light mean?

ANSWER: Failure of the anti-skid system.

Question 4 — 1.4.11.2.1
How fast must the wheels spin before the anti-skid system begins operating and at what speed does the system shut itself down?

ANSWER: The anti-skid system begins operating when the wheels have spun up to 30 kts and shuts itself down when speed slows to 10-13 kts ground speed.

Question 5 — 1.4.9.2.1
What is the nosewheel steering range in high gain and how is it selected?

ANSWER: +/- 65 degrees, pressing and holding the NWS button.

Question 6 — 1.4.13.3
What is the function of the HOOK BYPASS switch when set to the FIELD position?

ANSWER: It disables the flashing of the AOA indexer and approach lights when the aircraft is in landing configuration with the hook retracted.

III. Aircraft interfaces **1.4.9.2**, **1.4.12.2**, **1.4.10.2**, **1.4.11.2**, **1.4.13.2**

Sg 3, fr 2
Lesson Organization

HYDRAULIC SUBSYSTEMS

* Landing gear system
* Landing gear-related components
* **Aircraft interfaces**

? **With what aircraft systems do the hydraulic subsystems interface?**

ANSWER: HYD 1, electrical, centralized warning system, and weight-on-wheels

A. Hydraulic system

1. All hydraulic subsystem items powered by HYD 1

2. If HYD 1 fails, services retained due to backup/ alternate means include

   a. Landing gear: gravity free-fall extension and lock

   b. Forward NLG doors partially closed electrically

   c. Arresting hook: gravity/pneumatic extension

   d. Wheel brakes: wheel brake/emergency flap accumulator provides enough braking for one normal landing

   e. Flaps: full extension

3. If HYD 1 fails, services lost include

   a. NWS: use differential braking instead

   b. Anti-skid: must be selected OFF to conserve wheel brake/emergency flap accumulator pressure for wheel brakes

c. Launch bar extension: will retract due to mechanical (spring) pressure

d. Arresting hook retraction

e. Landing gear and MLG door retraction

f. Slats: remain in position set when HYD 1 lost

B. Electrical system

1. 28 VDC essential services bus

a. Arresting hook (up/down proximity switches, hook warning lights)

NOTE: The arresting hook itself is mechanically controlled and gravity operated with pneumatic assist. Even if batteries or the essential services bus itself fails, the hook will extend.

b. Landing gear control (control and lights)

(1) If power to essential services bus fails, normal gear extension not possible

(2) Emergency gear extension system (mechanical) will still be operable

c. Landing gear position indicator (light in handle)

d. WOW control

e. Anti-skid control: available with generator failure

f. Nose wheel steering: available with generator failure

2. 28 VDC essential service bus: cannot extend launch bar with total electrical failure; retraction automatic due to spring force without commanded hydraulics

Sg 3, fr 3
Fig 24: *Centralized Warning System Interface*

C. Centralized warning system (CWS) inputs: signals illuminate caution lights (with accompanying MASTER ALERT light and caution tone)

1. SKID or NWS caution light if BIT failure or NWS paddled off

2. PK BRK caution light when handle set and throttle advanced past intermediate (70%) setting

3. BRK PRESS caution light if brake pressure fails to release prior to catapult launch

4. SKID or NWS HI advisory light indicates normal operation

5. HOOK warning light (not accompanied by MASTER ALERT light and warning tone) when selected hook position does not match actual hook position

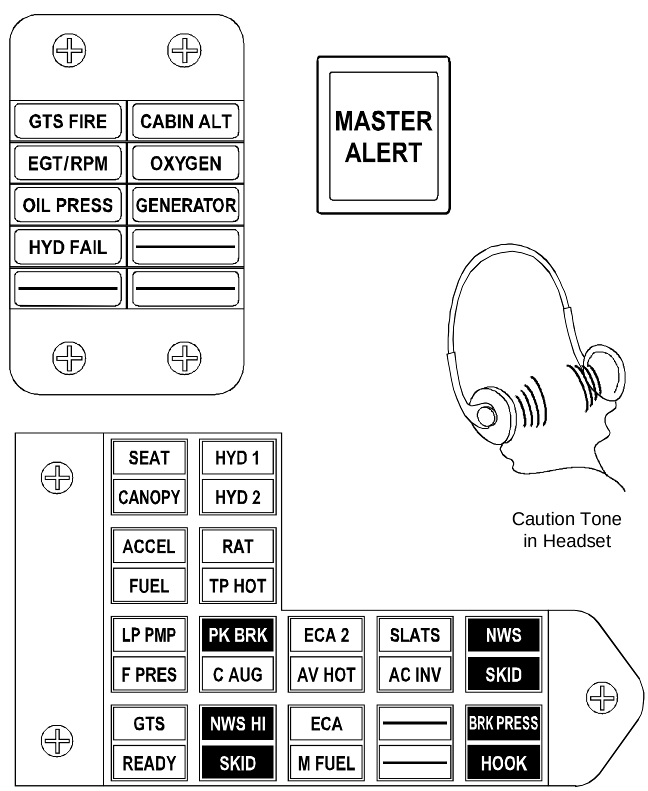


Figure 24: CENTRALIZED WARNING SYSTEM INTERFACE

Sg 3, fr 4
Fig 25: *Weight-on-Wheels (WOW)*

D. Weight-on-wheels (WOW) and gear-down/up-and -locked control

1. Location of proximity switches

a. Main gear

b. Nose gear

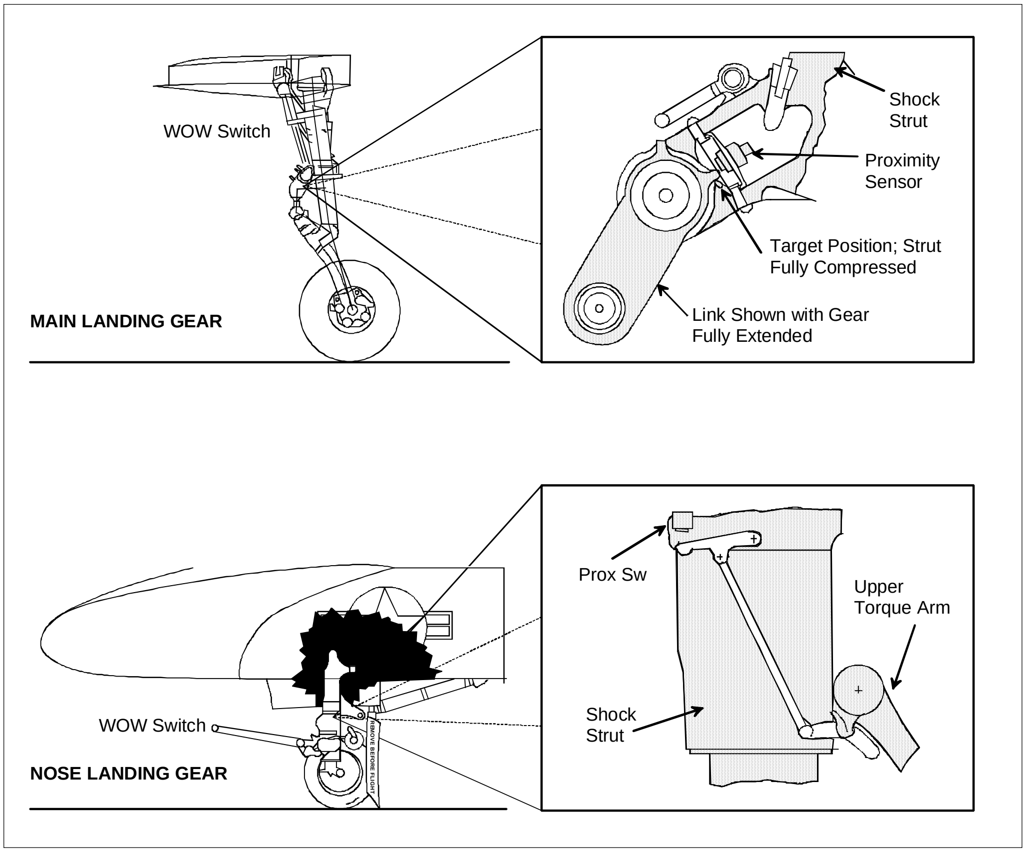


Figure 25: WEIGHT-ON-WHEELS (WOW)

2. Weight-<u>off</u>-wheels condition

a. Monitored by airborne data recorder

b. Closes environmental control system (ECS) ram air valve

c. Disables NWS system

d. Selects airborne mode of anti-skid system to provide touchdown protection upon landing

e. Enables AOA probe

f. Selects in-flight avionics cooling mode

g. Disables launch bar extension

3. Weight-on-wheels condition

   a. Monitored by airborne data recorder

   b. Opens ECS ram air valve

   c. Selects ground avionics cooling mode

   d. Disables emergency jettison of external stores

   e. Disables armament bus

   f. Enables NWS

   g. Removes power to AOA probe

   h. Prevents retraction of landing gear

   i. Enables launch bar extension

   j. Enables HUD system to input mission data

4. Gear down and locked condition

   a. Monitored by airborne data recorder

   b. Condition indicated by gear position lighting

   c. Enables yaw damping system

   d. Activates a hold-down relay to keep the FUEL caution light illuminated once it has activated. This prevents sloshing fuel from turning FUEL caution light (with accompanying MASTER ALERT and caution tone) on and off

e. Enables AOA approach lights to flash when HOOK BYPASS switch in CARRIER position and hook not down

f. Controls navigation mode display on HUD (approach mode)

g. Opens IPRSOV to enhance efficiency of ECS

h. Required condition for the brake pressure release system to activate

5. Gear up and locked condition

a. Monitored by airborne data recorder

b. Gear position lighting

c. Controls navigation mode display on HUD (cruise mode)

d. Closes IPRSOV

E. Interface summary:

The hydraulic subsystems interface with the following four basic aircraft systems: HYD 1, electrical system, CWS, and the WOW sensors. Additionally, the position of the landing gear affects the operation of various aircraft systems.

All hydraulic subsystems are powered by HYD 1 hydraulic pressure. If HYD 1 fails, the following subsystems rely on emergency backup systems: landing gear/gear door extension, forward NLG door closure, arresting hook extension, wheel brakes, and flaps. The following subsystem functions are no longer usable: NWS, anti-skid, launch bar extension, arresting hook retraction, landing gear/MLG gear door retraction and slats operation.

The hydraulic subsystems receive electrical power from the 28 VDC essential services bus, and the 28 VDC generator bus. The 28 VDC essential services bus powers the arresting HOOK warning light, the LDG GEAR UP/DN handle, landing gear down and locked advisory lights, NWS, anti-skid, brake pressure release system and the WOW system. Emergency extension of the landing gear is required if the 28 VDC essential services bus fails.

The following hydraulic subsystems provide inputs to the CWS: slats, anti-skid, NWS, launch bar, and parking brake. Unlike the slats, anti-skid, launch bar, and NWS inputs, the parking brake input is simply an indication that the parking brake handle is extended when the throttle position has been advanced beyond approximately 70% rpm N_2.

The WOW sensors signal various aircraft systems as to whether the aircraft is airborne or on the deck. These sensors report this status to the airborne data recorder. Depending on the condition reported, several hydraulic subsystem functions are either enabled or disabled. If a weight-off-wheels condition exists, the NWS system is disabled, extension of the launch bar is prevented, and the anti-skid touchdown protection mode is enabled. If a weight-on-wheels condition exists, the NWS system is enabled and launch bar extension is enabled.

The position of the landing gear is monitored by the airborne data recorder and affects aircraft operations as follows. If the gear is down and locked, gear down position lighting is activated, the FUEL caution light remains on once illuminated, the AOA approach lights flash when the HOOK BYPASS switch is set to CARRIER (if the hook is not extended), and the approach mode display of the HUD is enabled. If the gear is up and locked, the landing gear handle position lighting is disabled, and the cruise mode display of the HUD is enabled.

Sg 10, fr 2
Review Menu

SUMMARY

This lesson has presented information on the major components, controls and indicators, operational characteristics, and limitations of the hydraulic subsystems, including the landing gear system, the NWS, the launch bar system, and the arresting hook system.

Preflight checks and services for each of the hydraulic subsystems and the interfaces between these subsystems and other aircraft systems were also covered.

Remember in particular the controls and indicators associated with each subsystem, the operational characteristics of each subsystem, and the interfaces between the subsystems and other T-45C systems.

CONCLUSION

Knowing the hydraulic subsystems and recognizing the significance of cockpit indications are critical to completing your flight successfully and returning with your aircraft.

NOTES

LESSON GUIDE

COURSE/STAGE: TS, ADV & IUT / Engineering

LESSON TITLE: Hydraulic Subsystems Malfunctions

LESSON IDENTIFIER: T-45C TS, ADV & IUT   ENG-12

LEARNING ENVIRONMENT: CAI

ALLOTTED LESSON TIME: 1.0 hr

TRAINING AIDS:

* Figures
  - Fig 1: Hydraulic System
  - Fig 2: (FWD) Cockpit Instrument Panel and Consoles
  - Fig 3: Landing Gear/Door System Operation
  - Fig 4: Wheel Brake/Anti-Skid System Operation
  - Fig 5: Nose Wheel Steering System Operation
  - Fig 6: Launch Bar System Operation
  - Fig 7: Tail Hook System Operation

STUDY RESOURCES:

* T-45C NATOPS Pilot's Pocket Checklist, A1-T45AC-NFM-500
* <u>T-45C NATOPS Flight Manual</u>, A1-T45AC-NFM-000

(9-98) CHANGE 1

LESSON PREPARATION:

Read:

* Part I, Chapter 2.9 “Landing Gear System,” 2.10 “Nose Wheel Steering System,” 2.11 “Wheel Brake/Anti-Skid System,” 2.12 “Launch Bar System,” and 2.13 “Arresting Hook System,” <u>T-45C NATOPS Flight Manual</u>, A1-T45AC-NFM-000

Review:

* Lecture Guide for Eng-09, “Hydraulic System”
* Lecture Guide for Eng-11, “Hydraulic Subsystems”

REINFORCEMENT: N/A

LESSON EXAMINATION:

Student is required to read hydraulic subsystem and related malfunction paragraphs in the NATOPS Flight Manual, receive classroom instruction, and complete assigned CAI lesson(s). The student shall demonstrate knowledge by completing, from memory with 80% accuracy, true/false and multiple choice block examinations. The objectives in this lesson will be tested in either Engineering 29X or Engineering 30X.

LESSON OBJECTIVES

1.5.4.3.1
Identify indications of unsafe gear on retraction

1.5.4.6.1
Identify indications of gear door malfunctions

1.5.1.4.3.1
Identify indications of wheel brake failure

1.9.3.10.1
Identify indications of wheel brake/emergency flap accumulator failure

1.9.3.9.1
Identify indications of anti-skid failure

1.5.1.4.4.1
Identify indications of parking brake failure

1.5.1.4.2.1
Identify indications of NWS failure

1.5.4.5.1
Identify indications of launch bar failure

1.9.3.15.1
Identify indications of tail hook malfunctions in the landing phase

MOTIVATION

Although these malfunctions are presented separately, one malfunction might well cause another. Likewise, multiple, unrelated malfunctions could occur simultaneously. In the simulator, they certainly will. Later in the curriculum, you'll learn the precise emergency procedures to take in response to each of the malfunctions described in this lesson.

OVERVIEW

This lesson will help you to recognize and analyze hydraulic subsystem malfunctions in a logical cause-and-effect sequence, beginning with a visual review of how the subsystem should function and addressing the malfunctions in three phases:

* Indications
* Verifications
* Effects on flight safety

This lesson presents the following hydraulic subsystem malfunctions:

* Unsafe gear on retraction
* Gear door malfunctions
* Wheel brake failure
* Wheel brake/emergency flap accumulator failure
* Anti-skid failure
* Parking brake failure
* Nose wheel steering (NWS) failure
* Launch bar failure
* Tail hook malfunctions in the landing phase

REFRESHER

Fig 1: Hydraulic System

Fig 2: Cockpit Instrument Panels and Consoles

Recall the hydraulic system normal operation.

Recall the location and function of:

* Controls and indicators related to the hydraulic subsystems that are found on the left and right cockpit consoles and the control stick
* Cockpit main instrument panel hydraulic subsystem controls and indicators

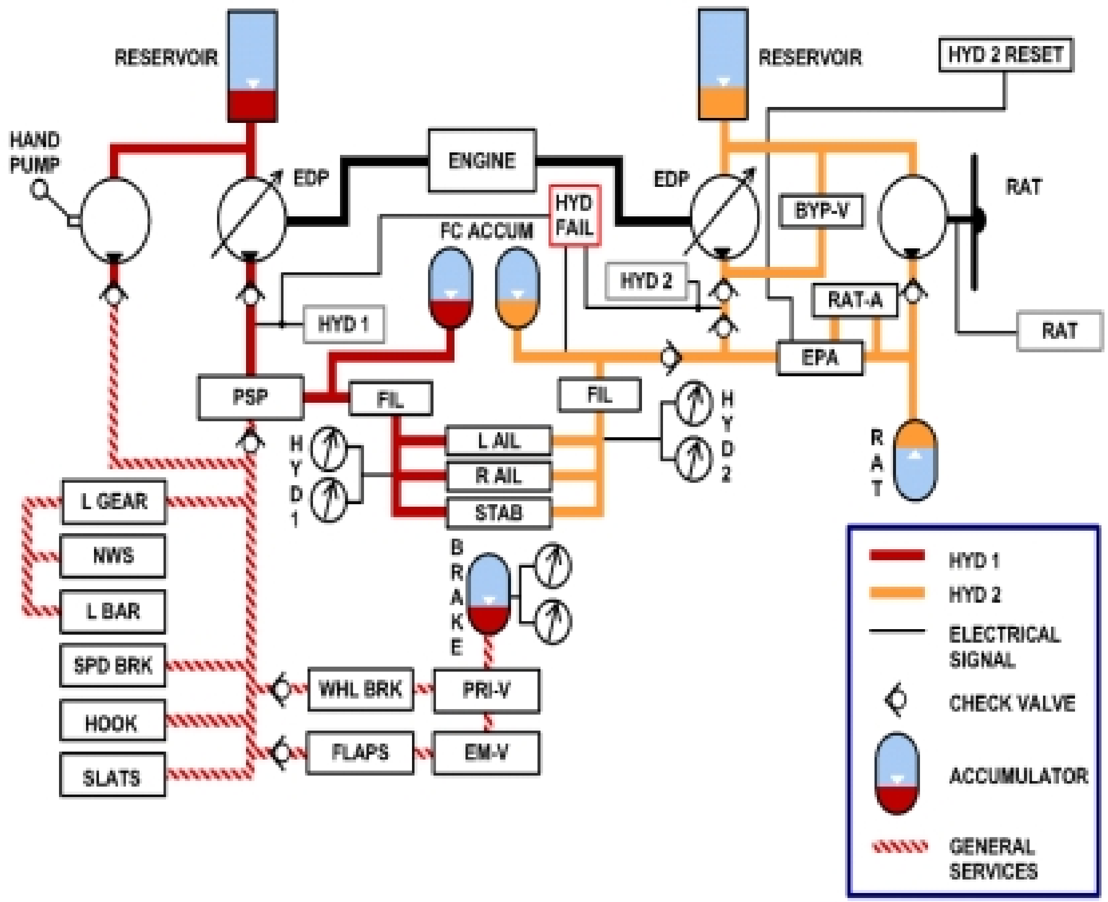


Figure 1: HYDRAULIC SYSTEM

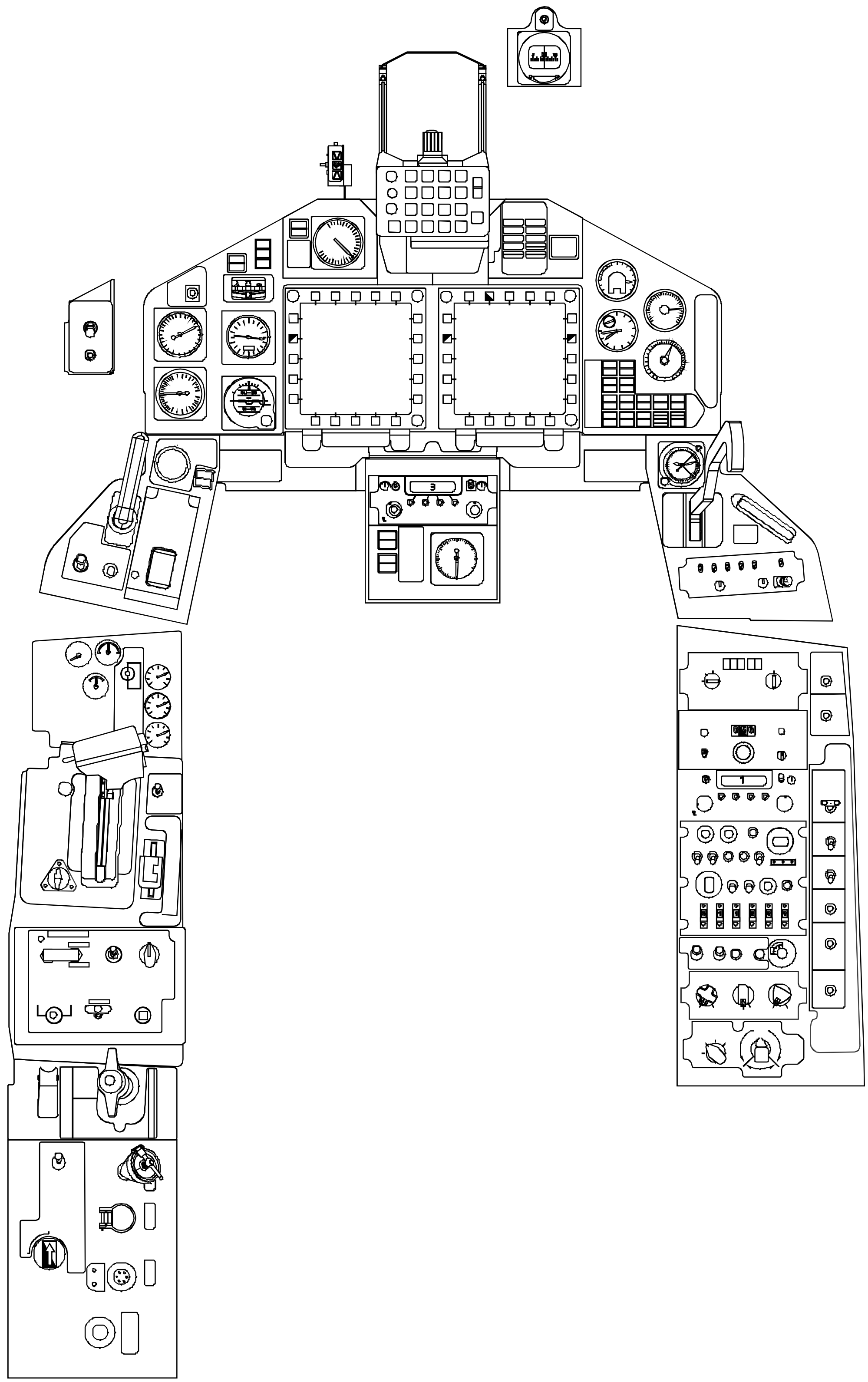


Figure 2: (FWD) COCKPIT INSTRUMENT PANEL AND CONSOLES

PRESENTATION

I. Unsafe gear on retraction

Fig 3: Landing Gear/ Door System Operation

A. Indications

1. Landing gear handle light remains illuminated (red)
2. Gear retraction requires excessive time period
3. Normal sounds and feel of gear retraction not present
4. Landing gear door light remains lit

B. Verifications

1. One or more landing gear indicator lights (NOSE, LEFT, RIGHT) may remain illuminated

   NOTE: The NOSE, LEFT, and RIGHT lights illuminate green for down and locked.

2. LDG GEAR DOOR light will remain illuminated

   NOTE: If landing gear fails to fully retract, the system may also identify a malfunction in the landing gear.

3. HYD 1 pressure gauge may indicate pressure loss
4. Wind noise/drag from landing gear/gear doors may be apparent, and yaw may occur with one main down

C. Effects on flight safety

1. Airspeed restricted to less than 200 KIAS
2. Excess drag will increase fuel consumption
3. With gear jammed, extension may not be possible
4. If HYD 1 pressure gauge indicates pressure loss, emergency gear extension may be required

II. Gear door malfunction

Fig 3: Landing Gear/ Door System Operation

A. Indications: LDG GEAR DOOR light remains illuminated

NOTE: Landing gear retraction should occur in approximately 10 seconds, extension in approximately 15 seconds.

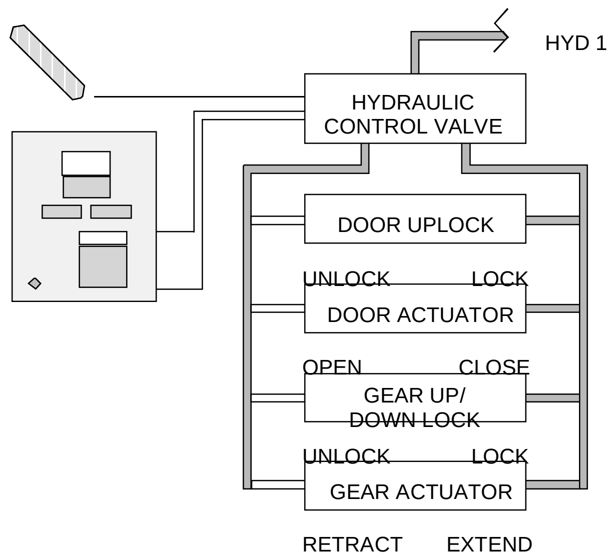


Figure 3: LANDING GEAR/DOOR SYSTEM OPERATION

B. Verifications

1. In retract mode, landing gear handle light remains illuminated (red)

2. Wind noise/drag from landing gear doors may be apparent

3. Visual by other aircraft or tower, if available

C. Effects on flight safety

1. Airspeed restricted to less than 200 KIAS

2. Open door fouls the arresting gear

III. Wheel brake failure

Fig 4: Wheel Brake/ Anti-Skid System Operation

A. Indications

1. Lack of brake pedal pressure (one or both pedals)

2. Aircraft fails to slow when brake pedal pressure applied

3. Aircraft pulls to left or right upon application of brake pedal pressure

B. Verifications: indications are verification

C. Effects on flight safety

1. Loss or reduction of ability to control speed on ground

2. Loss of differential braking

3. Loss of anti-skid

IV. Wheel brake/emergency flap accumulator failure

Fig 4: Wheel Brake/ Anti-Skid System Operation

A. Indications: wheel brake/emergency flap accumulator pressure gauge in starboard wheelwell and left console BRAKE gauge display 0 psi

NOTE: Under normal conditions the wheel brake/emergency flap accumulator pressure gauge and brake gauge should display a minimum of 1300 psi on preflight and 3000 psi with the engine operating.

B. Verifications: braking may be jerky and/or uneven

C. Effects on flight safety

1. No backup brake system if HYD 1 inoperative

2. No backup flaps system if HYD 1 inoperative

NOTE: Slats not available. Slats do not have a backup.

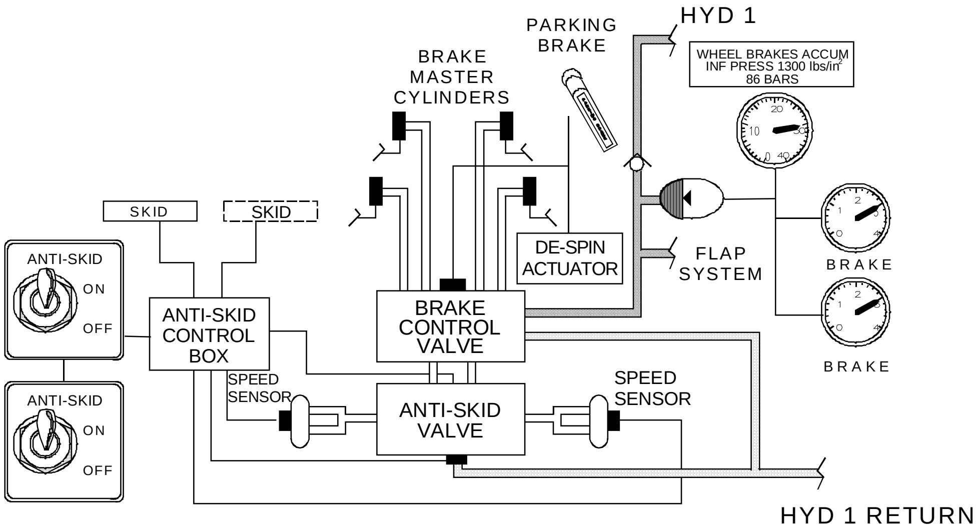


Figure 4: WHEEL BRAKE/ANTI-SKID SYSTEM OPERATION

V. Anti-skid failure

A. Indications

1. MASTER ALERT light flashes

2. Caution tone sounds in headsets

3. SKID caution light illuminated

B. Verifications: same as indications

C. Effects on flight safety

1. Touchdown protection mode (2-second wheel brake lockout) of ANTI-SKID system will be inoperative

2. Stopping distance increases and arrested landing may be required

Fig 4: Wheel Brake/ Anti-Skid System Operation

VI. Parking brake failure

Fig 4: Wheel Brake/ Anti-Skid System Operation

A. Failure to engage

1. Indications: aircraft fails to hold ground position

NOTE: The parking brake may be used as a backup to the wheel brakes when taxiing in the event of a wheel brake failure.

2. Verifications: wheel brake/emergency flap accumulator pressure gauge indicates 1300 to 3000 psi

3. Effects on safety

a. If parking brake failure combines with wheel brake failure, aircraft braking system has failed completely

b. Alternative methods of securing aircraft ground position will be required

B. Failure to disengage

1. Indications

a. Aircraft fails to roll properly with parking brake handle disengaged

Note: There are no secondary indications on the warning caution advisory panels of a parking brake failing to disengage.

2. Verifications: parking brake control set to disengage

3. Effects on safety: difficult or impossible to move aircraft without assistance

C. Parking brake caution light

1. Indications:

a. MASTER ALERT light flashes

b. Caution tone sounds in headsets

c. PK BRK caution light illuminated

NOTE: The proceeding indications will appear only when the throttle is advanced to midpoint.

a. Power advanced above 70%

b. Parking brake handle in the ON position

C. Effects on flight safety

1. Prevents landing/taxi attempts with parking brake engaged

Fig 5: *Nose Wheel Steering System Operation*

VII. NWS failure

A. Indications

1. MASTER ALERT flashes

2. Caution tone sounds in headsets

3. NWS caution light illuminated

4. Nose wheel fails to respond to input commands

B. Verifications: NWS HI advisory light <u>not</u> illuminated if operating in high gain

C. Effects on safety

1. Alternative methods of steering aircraft on ground (i.e., differential braking, rudder deflection) will be required

2. If hydraulic steering motor fails, nose wheel could be locked to the left or right

NOTE: If the landing gear is emergency extended, hydraulic pressure will not be supplied to the nose wheel steering and the system will be inoperative.

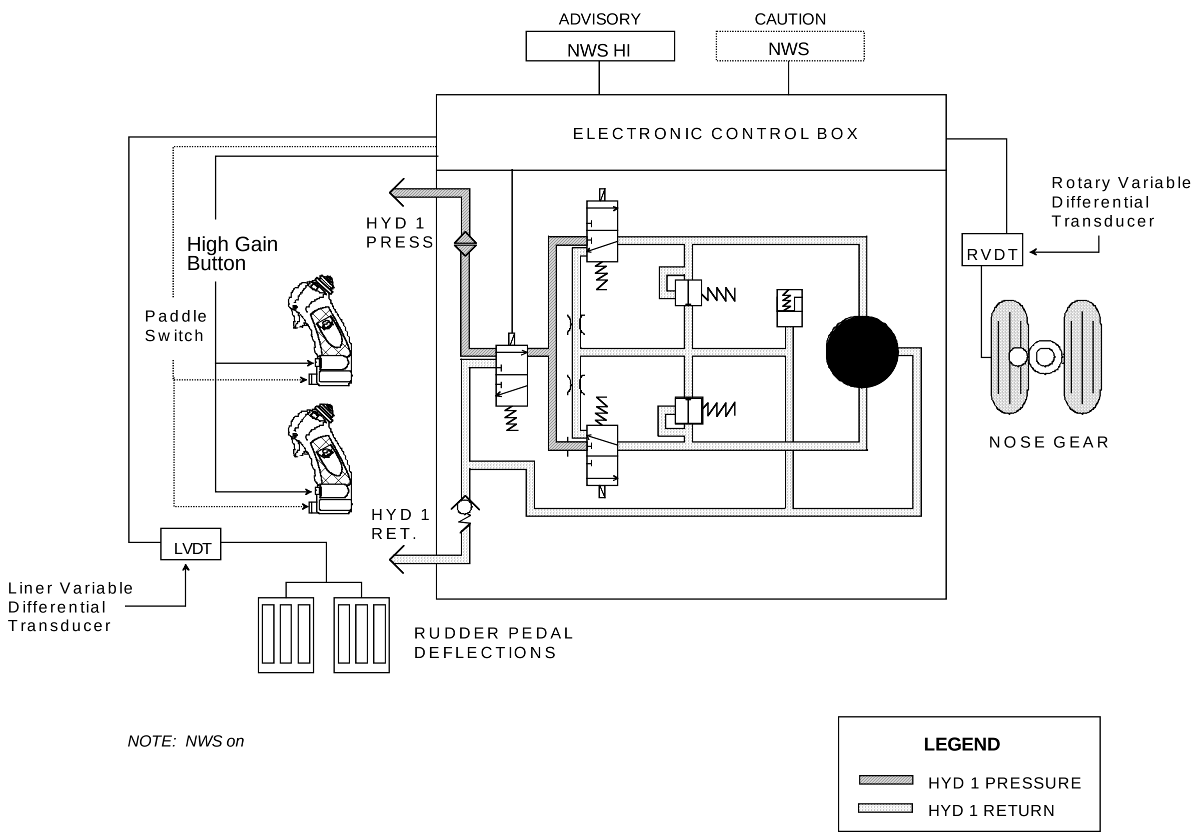


Figure 5: NOSE WHEEL STEERING SYSTEM OPERATION

Fig 6: Launch Bar System Operation

VIII. Launch bar failure

A. Failure to extend

NOTE: This malfunction affects only catapult-assisted takeoff.

1. Indications: L BAR green (extended) indicator <u>not</u> illuminated after EXTEND selected on deck

2. Verifications: ground crew visual

3. Effects on safety: catapult-assisted takeoff impossible

B. Failure to retract

1. Indications

NOTE: There is a 10 sec delay in the launch bar failure to retract, warning circuitry after airborne with gear down.

a. MASTER ALERT flashes

b. Warning tone sounds in headsets

c. L BAR red (not retracted) light illuminates

d. With landing gear retracted, indications will cease but problem may still exist

2. Verifications: if available, tower/other aircraft visual inspection

3. Effects on flight safety

a. When landing gear extended again, malfunction and associated indications may reappear

b. Arrested landing not permitted

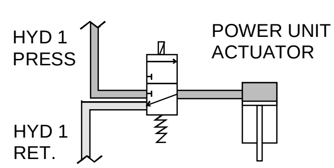


Figure 6: LAUNCH BAR SYSTEM OPERATION

Fig 7: Tail Hook System Operation

IX. Tail hook malfunctions in the landing phase

A. Indications

1. Arresting hook handle warning light (red) remains illuminated following commanded EXTEND

   NOTE: Arresting hook extension should occur within 1.5 seconds.

2. Arresting hook handle warning light may illuminate intermittently

   NOTE: Intermittent illumination of the arresting hook handle red light indicates that the arresting hook is bouncing--a condition caused by a malfunctioning hydraulic actuator/vertical damper.

3. Arresting hook handle light remains illuminated for more than 6 seconds following commanded RETRACT

B. Verifications: other aircraft/tower visual inspection, if available

C. Effects on flight safety

1. Arrested landing not possible if hook fails to extend

2. Hook skip may prevent normal arrested landing

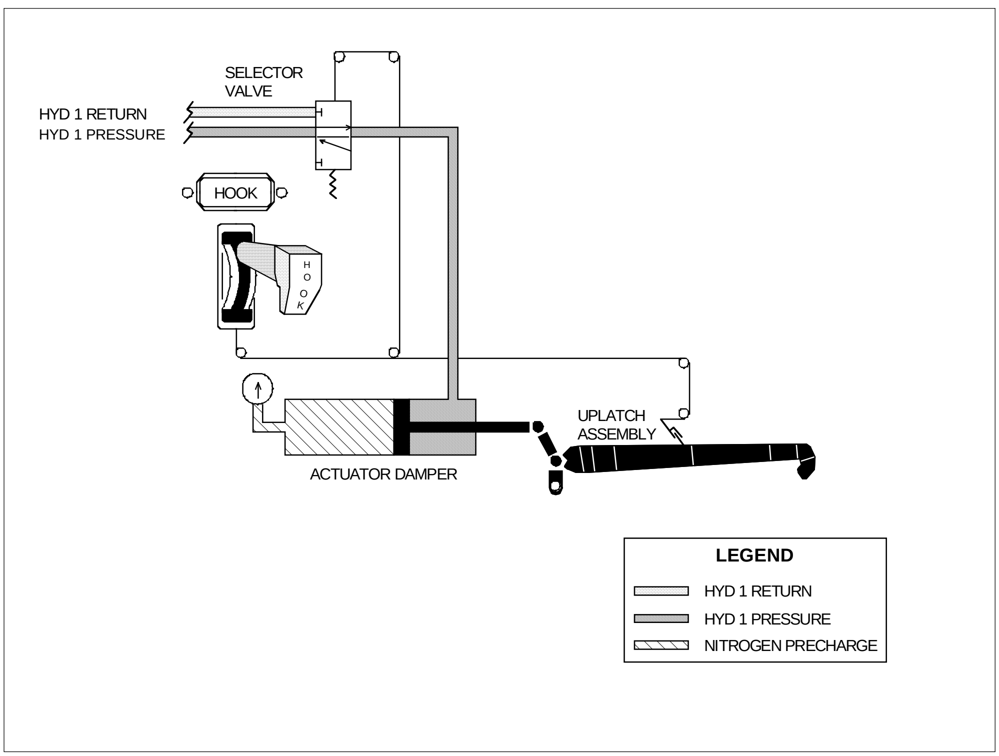


Figure 7: TAIL HOOK SYSTEM OPERATION

LECTURE GUIDE

COURSE/STAGE: TS, ADV & IUT / Engineering

LESSON TITLE: Flight Control System

LESSON IDENTIFIER: T-45C TS, ADV & IUT ENG-13

LEARNING ENVIRONMENT: Classroom

ALLOTTED LESSON TIME: 1.3 hr

TRAINING AIDS:

* T-45 Scale Model
* Wall Charts
  Cutaway View T-45C
  T-45C Cockpit
* Figures
  Fig 1: Flight Control System, Flaps/Slats, Speed Brakes
  Fig 2: Flight Controls--Aileron System Components
  Fig 3: Aileron Controls/Indicators
  Fig 4: Aileron System Components--Simplified
  Fig 5: Flight Controls--Stabilator System Components
  Fig 6: Stabilator Controls/Indicators
  Fig 7: Stabilator System Components--Simplified
  Fig 8: Flight Controls--Rudder System Components
  Fig 9: Rudder Controls/Indicators
  Fig 10: Rudder System Components--Simplified
  Fig 11: Flap System Components--Simplified

(9-98) CHANGE 4

TRAINING AIDS:

Fig 12: Flap Controls/Indicators
Fig 13: Slat System Components--Simplified
Fig 14: Slat Controls and Indicators
Fig 15: Speed Brake System Components--Simplified
Fig 16: Speed Brake Controls/Indicators
Fig 17: Flap System Components
Fig 18: Slat System Components
Fig 19: Speed Brake System Components
Fig 20: Hydraulic System Block Diagram

STUDY RESOURCES:

* T-45C NATOPS Flight Manual, A1-T45AC-NFM-000

LESSON PREPARATION:

Read:

* Part I, Chapter 2.5, "Flight Controls and Trim System," and Chapter 2.6, "FLAP/SLAT System," in the T-45C NATOPS Flight Manual, A1-T45AC-NFM-000

REINFORCEMENT: N/A

EXAMINATION:

Student is required to read flight control system paragraphs in the NATOPS Flight Manual, receive classroom instruction, and complete assigned CAI lesson(s). The student shall demonstrate knowledge by completing, from memory with 80% accuracy, true/false and mulitple choice block examinations. The objectives in this lesson will be tested in either Engineering 29X or Engineering 30X.

SUMMARY

This lesson has presented indications of the following hydraulic subsystem malfunctions:

* Unsafe gear on retraction
* Gear door malfunctions
* Wheel brake failure
* Wheel brake/emergency flap accumulator failure
* Anti-skid failure
* Parking brake failure
* NWS failure
* Launch bar failure
* Tail hook malfunctions in the landing phase

CONCLUSION

This lesson has given you the information needed to recognize hydraulic subsystem malfunctions and to assess their impact on aircraft operations and flight safety. The background information provided in this lesson is critical when you enter the simulator and aircraft and encounter simulated and actual hydraulic subsystem malfunctions.

If this lesson has raised any questions for you, be certain to contact your instructor.

LESSON OBJECTIVES

1.4.14.3.1
Recall major components of the flight control system

1.4.14.2.1
Recall operating characteristics of the flight control system

1.4.14.3.1.5
Recall major components of the aileron system

1.4.14.2.1.1
Recall operating characteristics of the aileron system

1.4.14.3
Recall function, purpose, and location of the flight control system controls, switches, and indicators

1.4.14.3.1.3
Recall major components of the stabilator system

1.4.14.2.1.2
Recall operating characteristics of the stabilator system

1.4.14.3.1.4
Recall major components of the rudder system

1.4.14.2.1.3
Recall operating characteristics of the rudder system

1.5.4.1.2.1
Recall operating characteristics of the flap/slat system

1.5.4.1.2.1.2
Locate flap/slat system controls and indicators

1.5.4.1.2.1.1
Recall flap/slat operating limitations

1.4.19.3.1
Recall major components of the speed brake system

1.4.19.2.1
Recall operating characteristics of the speed brake system

1.4.19.3
Recall function, purpose, and location of speed brake system controls, switches, and indicators

1.4.14.2
Recall interfaces between the flight control system and other a/c systems

1.5.4.1.2.1.5
Recall interfaces between the flap/slat system and other a/c systems

1.4.19.2
Recall interfaces between the speed brake system and other a/c systems

MOTIVATION

Thorough knowledge of the operating characteristics and limitations of the flight control system is vital to smooth and safe flight. This knowledge is also critical should a malfunction arise that requires a decision as to which procedures/techniques are best suited for dealing with the malfunction.

OVERVIEW

For the T-45C, you will learn the components and describe the purpose and functional characteristics of the flight control system, as well as the location of controls, switches, and indicators. You will also cover the flight controls and general services interfaces with other aircraft systems.

In this lesson we will be covering the:

* Major flight control components
* Flight controls
* Flaps/slats, speed brakes
* Aircraft systems interface

REFRESHER

* The T-45C flight controls are powered by two independent hydraulic systems and by pedal power.

PRESENTATION

? **Name the flight controls.**

ANSWER: Aileron, stabilator, and rudder

Sg 1, fr 2
Lesson Organization

FLIGHT CONTROL SYSTEM

* Major component identification
* Flight controls
* Flaps/slats, speed brakes
* Aircraft systems interfaces

Sg 1, fr 3
Fig 1: *Flight Control System, Flaps/Slats, Speed Brakes*

Sg 1, fr 4
Flight Controls

Sg 1, fr 5
Flaps/Slats

Sg 1, fr 6
Speed Brakes

Fig 1: *Flight Control System, Flaps/Slats, Speed Brakes*

I. Major flight control components **1.4.14.3.1**

A. Flight controls

1. Aileron system

2. Stabilator system

3. Rudder system

NOTE: Two stabilator vanes (strakes) are fixed surfaces located on each side of the rear fuselage, forward of the stabilator. With the flaps extended and a high angle of attack, they help direct airflow over the stabilator, providing enhanced aircraft pitch control.

B. Flaps/slats

C. Speed brakes

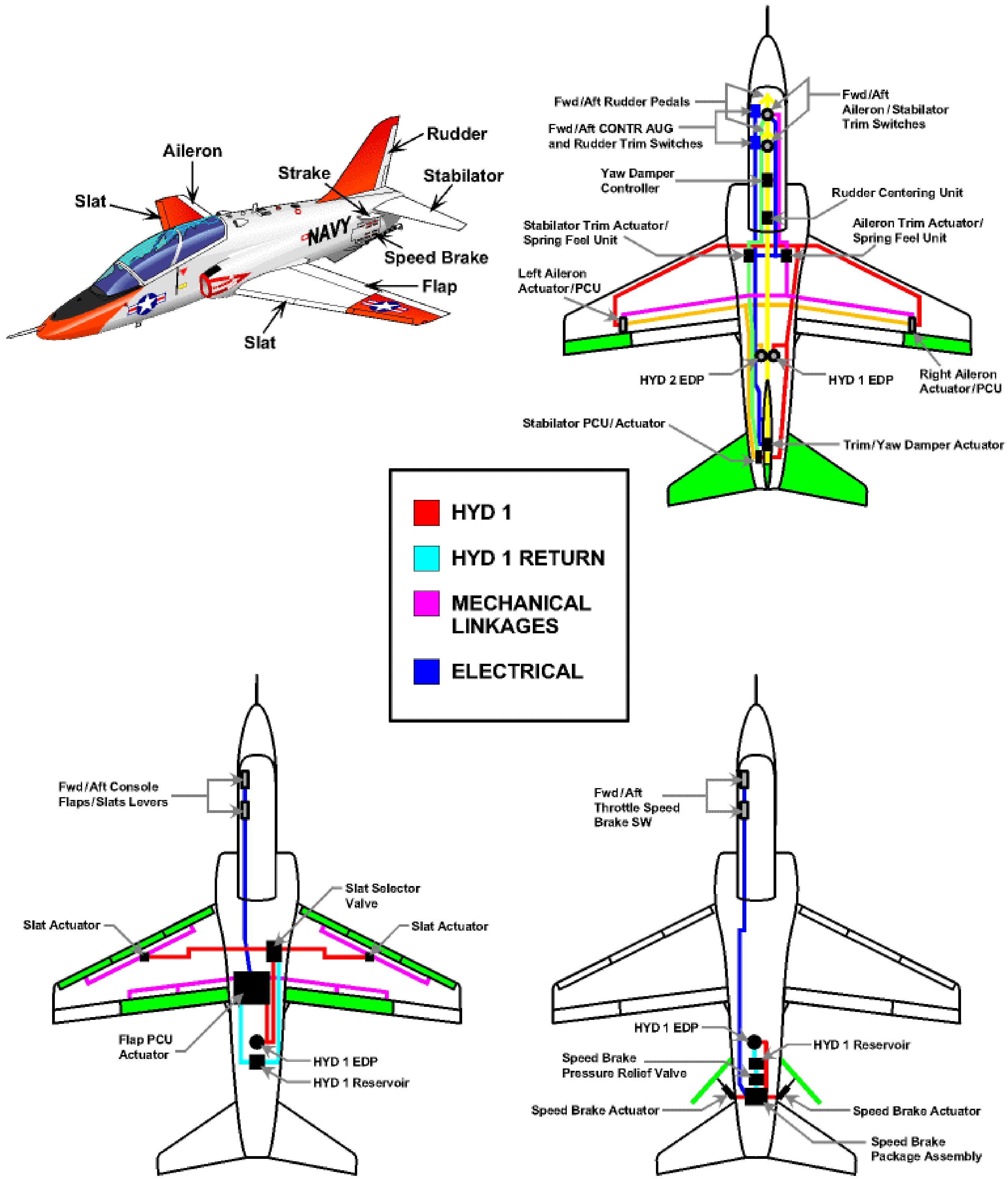


Figure 1: FLIGHT CONTROL SYSTEM, FLAPS/SLATS, SPEED BRAKES

Sg 2, fr 2
Lesson Organization

FLIGHT CONTROL SYSTEM

* Major component identification
* Flight controls
* Flaps/slats, speed brakes
* Aircraft systems interfaces

T45 Scale Model

Wall Chart: *Cutaway View T-45C*

Wall Chart: *T-45C Cockpit*

Sg 2, fr 3
(4 Overlays)
Fig 2: *Flight Controls--Aileron System Components*

Overlay 1
Ailerons

II. Flight controls **1.4.14.2.1**

A. Aileron system **1.4.14.3.1.5, 1.4.14.2.1.1, 1.4.14.3**

LESSON NOTES

Use the T-45 scale model to demonstrate the reaction of the aircraft to flight control system inputs. Use the T-45C cockpit and aircraft cutaway view wallcharts to identify controls, indicators, and components during this lesson.

1. Control surface components

NOTE: There are no aileron trim tabs on the T-45C.

a. Ailerons

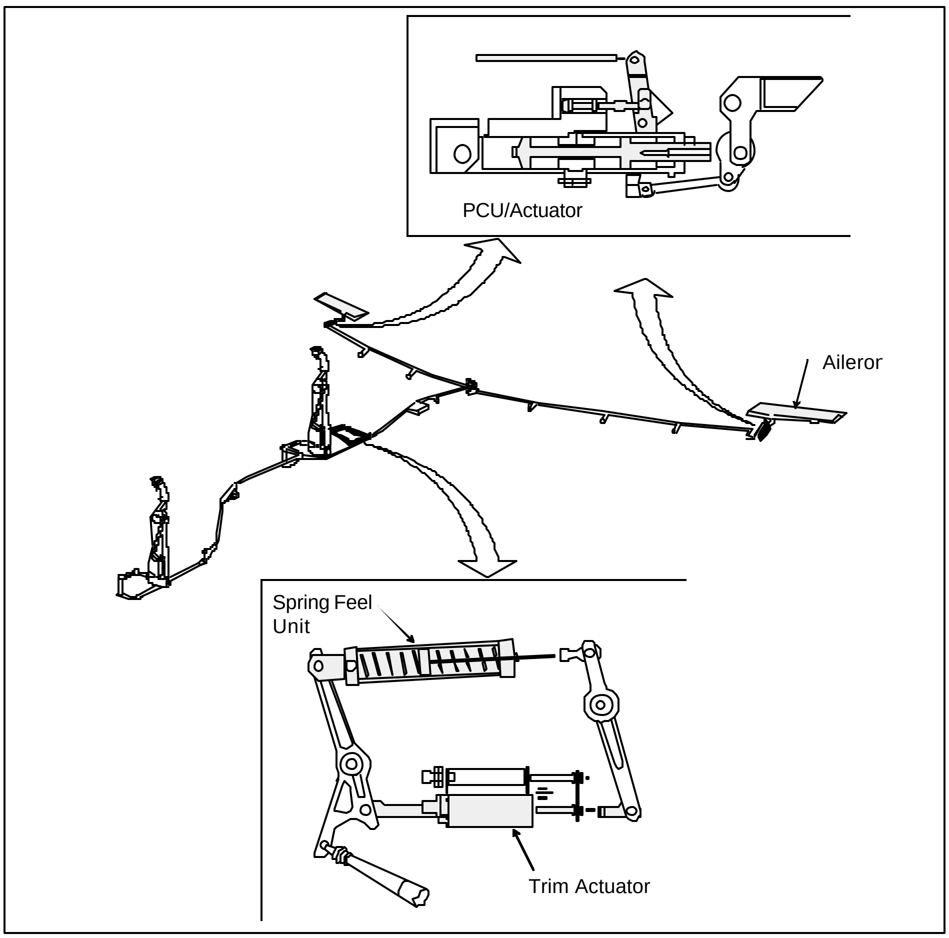


Figure 2: FLIGHT CONTROLS--AILERON SYSTEM COMPONENTS

(1) Location: outboard of flaps on trailing edge of wings

(2) Function

(a) Provide primary lateral control

(b) Provide lateral trim

b. Aileron actuators (power control units [PCUs])

Overlay 2
Aileron Actuators

(1) Location: mounted underneath wing trailing edge in fairings (one PCU per aileron)

(2) Function

(a) Supplied with power from both hydraulic systems for redundancy (two actuators per PCU)

(b) Provide mechanical power to move ailerons

c. Aileron trim actuator

Overlay 3
Aileron Trim Actuator

(1) Location: aft of aft cockpit floor, right of aircraft centerline

(2) Function: provides power to trim aileron control surfaces

d. Aileron spring feel unit

Overlay 4
Aileron Spring Feel Unit

(1) Location: just forward of trim actuators

(2) Function: provides pilot with artificial “feel” of aerodynamic forces acting on control surfaces

2. Cockpit controls/switches/indicators

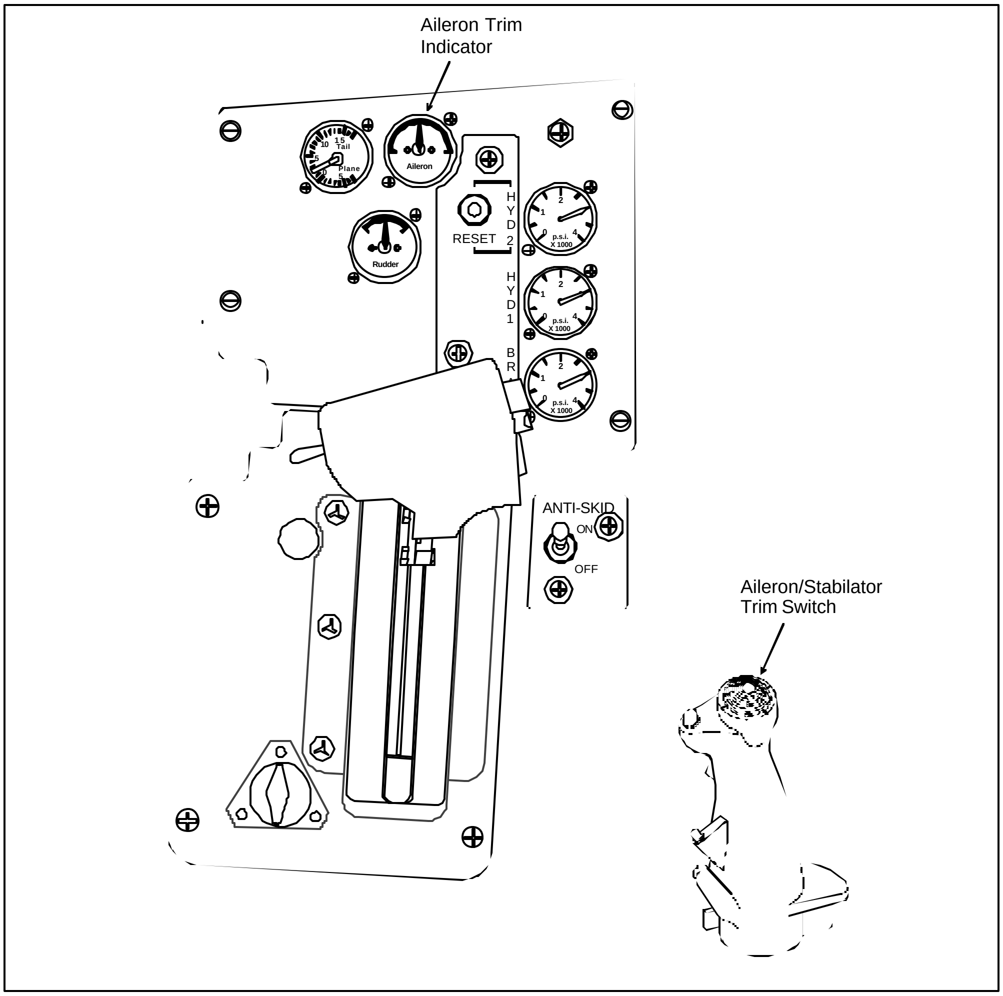


Figure 3: AILERON CONTROLS/INDICATORS

Sg 2, fr 8
Aileron/Stabilator Trim Switch

Sg 2, fr 9
Aileron Trim Indicator

Fig 3: *Aileron Controls/Indicators*

a. Aileron/stabilator trim switch

(1) Location: top of control sticks

(2) Function: five-position switch which provides for four-way trim

b. AILERON trim indicator (each cockpit)

(1) Location: left console, forward of throttle quadrant

(2) Function: shows position of aileron trim

3. Operating characteristics/limitations

   a. Each aileron powered by tandem hydraulic actuator (PCU)

      (1) Failure of either actuator will not affect remaining actuator

      (2) Failure of either hydraulic system will not affect operation

   b. Stick to aileron ratio changer increases aileron deflection and reduces maximum lateral stick deplacement when landing gear down

      (1) Maximum aileron deflection up and down is 12.5 degrees gear up and 15.5 degrees gear down

      (2) Maximum aileron trim deflection: 6 degrees up or down (with landing gear extended authority increases to +/- 9 degrees)

   c. Simultaneous operation of both trim switches in opposite directions disables the trim motor

Sg 2, fr 10
Fig 4: *Aileron System Components--Simplified*

? **What is the difference between elevators and stabilators?**

ANSWER: Elevators are attached to a fixed stabilizer and move up or down to control pitch (as on the T-34). A stabilator is one piece and the entire unit rotates to control pitch.

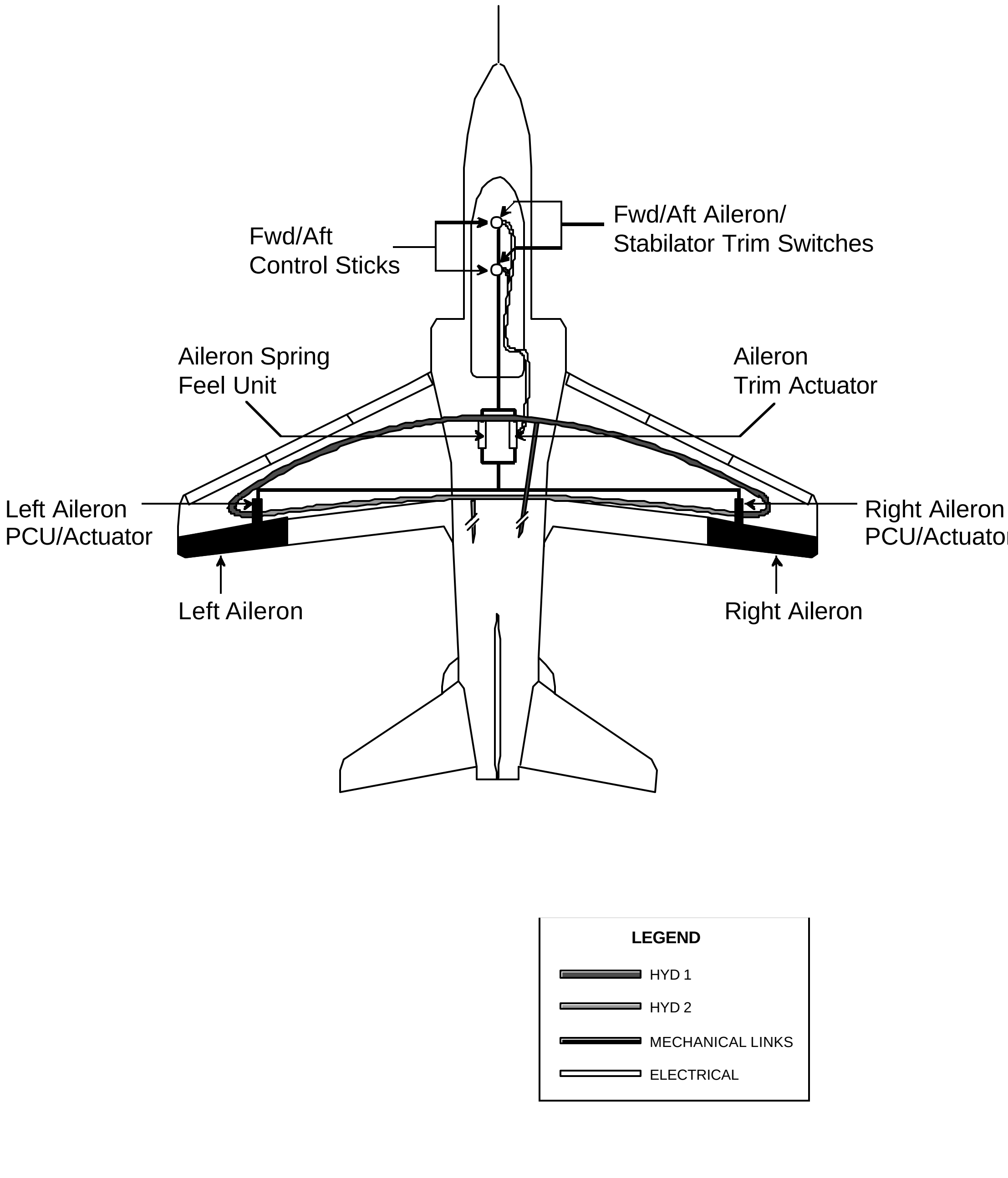


Figure 4: AILERON SYSTEM COMPONENTS--SIMPLIFIED

B. Stabilator system **1.4.14.3.1.3, 1.4.14.2.1.2, 1.4.14.3**

1. Control surface components

a. Stabilator

(1) Location: rear of aircraft fuselage

(2) Function: provides primary pitch control

b. Stabilator actuator (PCU)

(1) Location: mounted horizontally above engine tailpipe

(2) Function: mechanically controlled and hydraulically operated--provides power to move stabilator control surface

c. Stabilator trim actuator

(1) Location: just aft of aft seat frame

(2) Function: electrically controlled and mechanically operated--moves stabilator linkages providing trim inputs to the stabilator actuator

d. Stabilator spring feel unit

LESSON NOTES

Explain the difference between a system that does not have feedback pressure and the T-45C flight controls that feature simulated feedback. Compare the T-45C system to the T-34

Sg 2, fr 11
(4 Overlays)
Fig 5: *Flight Controls--Stabilator System Components*

Overlay 1
Stabilator

Overlay 2
Stabilator Actuator

Overlay 3
Stabilator Trim Actuator

Overlay 4
Stabilator Spring Feel Unit & Inertia Weight

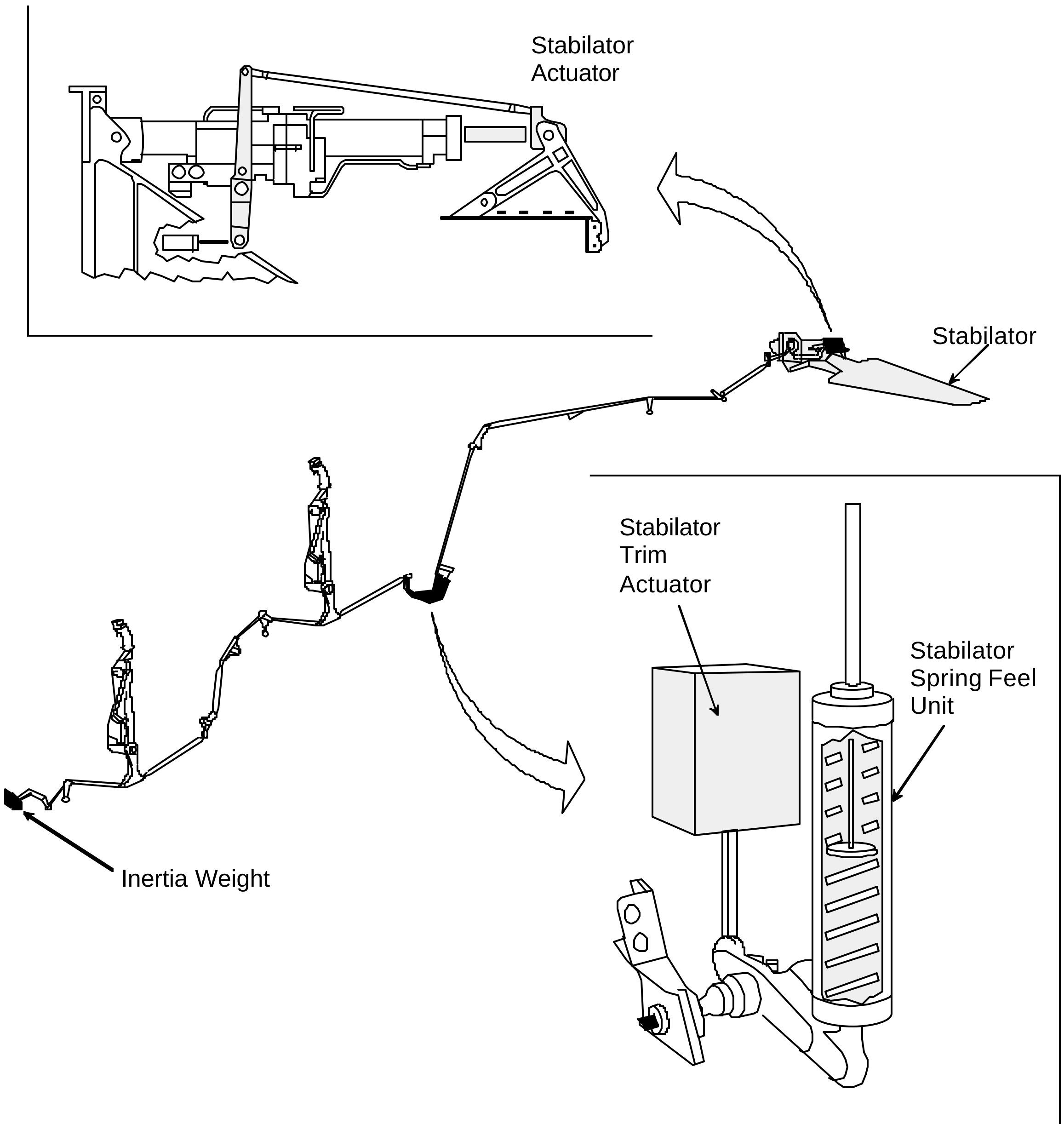


Figure 5: FLIGHT CONTROLS--STABILATOR SYSTEM COMPONENTS

(1) Location: adjacent to stabilator trim actuators

(2) Function: acts in conjunction with inertia weights and two viscous dampers to provide the pilot with artificial "feel" of aerodynamic forces acting on control surfaces

e. Speedbrake interconnect actuator

(1) Location: stabilator control box, forward of PCU

(2) Function: Sends speedbrake position signals to yaw damper controller. Receives input signals from yaw damper controller and moves stabilator to counter pitch transients due to speedbrake extension/ retraction

2. Cockpit controls/switches/indicators

a. Aileron/stabilator trim switch: located on top of control sticks

b. Standby stabilator trim (STBY STAB TRIM) switch (guarded): located on each left console

c. STABILATOR position indicator: located on left console, left of AILERON trim indicator

Sg 2, fr 16
Aileron/Stabilator Trim Switch

Sg 2, fr 17
(1 Overlay)
Stabilator Controls/ Indicators

Fig 6: *Stabilator Controls/Indicators*

Overlay 1
Stabilator Position Indicator

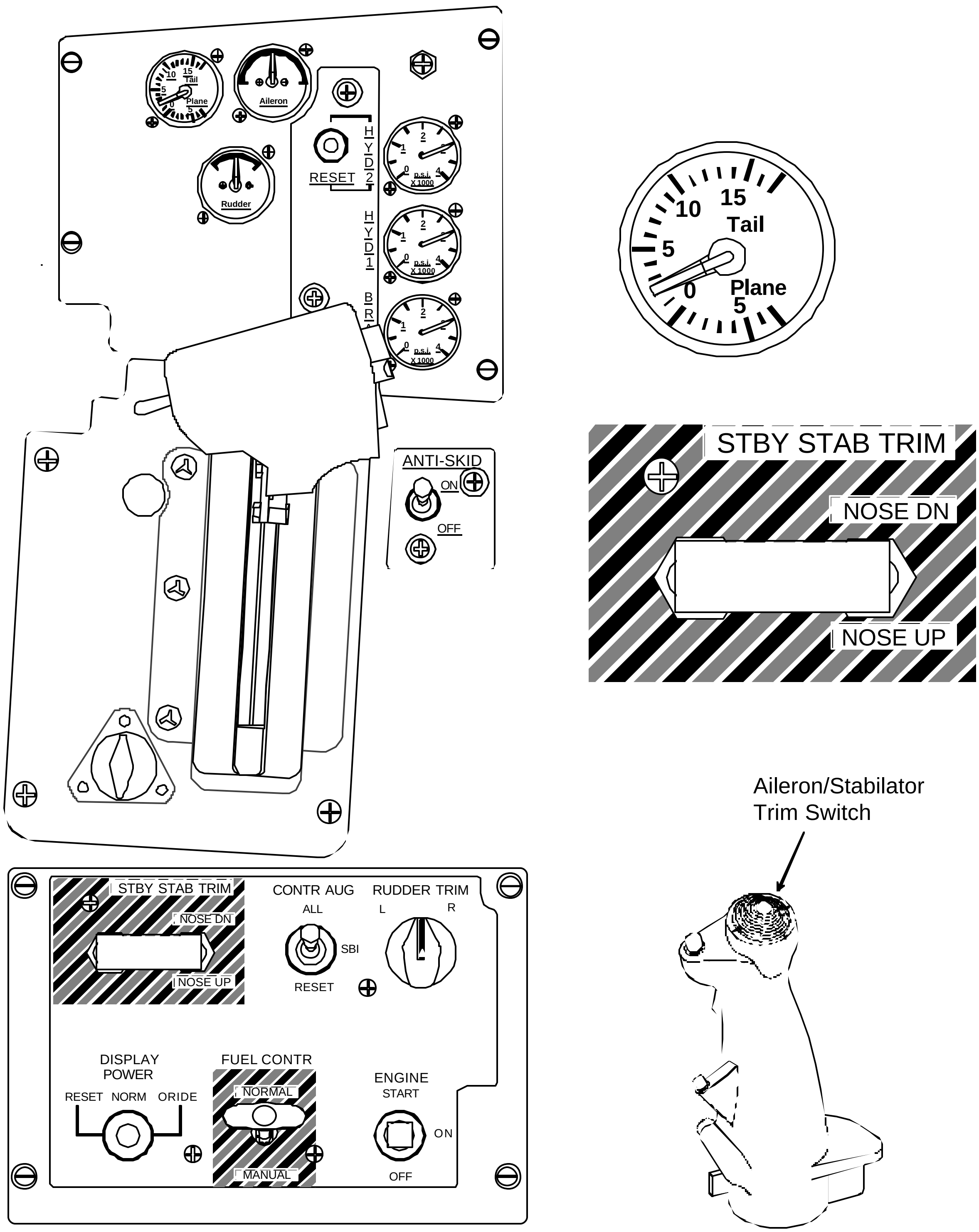


Figure 6: STABILATOR CONTROLS/INDICATORS

3. Operating characteristics/limitations

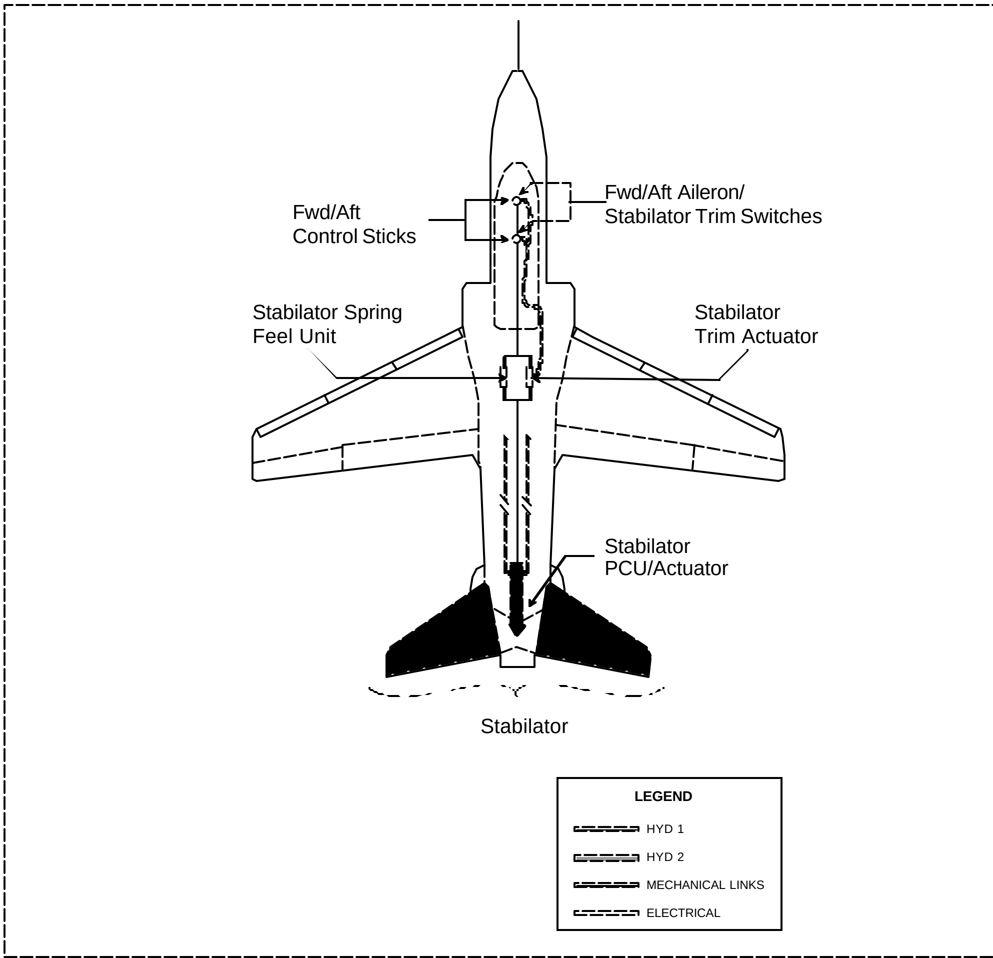


Figure 7: STABILATOR SYSTEM COMPONENTS -- SIMPLIFIED

Sg 2, fr 19
Fig 7: *Stabilator System Components--Simplified*

a. Stabilator powered by tandem hydraulic actuator: failure of either hydraulic system will not affect operation

b. Stabilator trim actuator consists of main and standby motor

(1) Main motor powered by 28 VDC essential bus. Operated by trim switch on control stick

(2) Standby motor powered by 28 VDC generator bus. Used in case of main motor failure. Controlled by STBY STAB TRIM switch

NOTE: Both motors are de-energized by travel limit switches. Lifting the STBY STAB TRIM switch guard disables the main trim motor and allows use of the standby trim switch.

c. Maximum stabilator deflection: control stick full aft—leading edge 15 degrees down; control stick full forward—leading edge 6.6 degrees up

d. Maximum stabilator trim deflection: provides a range from 3 degrees leading edge up to 8 degrees leading edge down

e. Simultaneous operation of the stabilator trim switches in opposite directions by both cockpits will disable the trim motor

f. Standby trim selection can be made from either cockpit and will disable main trim control

g. Rate of trim change from either main or standby control: approximately 2 degrees per second

Sg 2, fr 20
(5 Overlays)
Fig 8: *Flight Controls-Rudder System Components*

Overlay 1
Rudder

C. Rudder system **1.4.14.3.1.4, 1.4.14.2.1.3, 1.4.14.3**

1. Control surface components

a. Rudder

(1) Location: trailing edge of vertical stabilizer

(2) Function: provides primary yaw control

(3) Max deflection 20 +/- .5 degrees

Overlay 2
Rudder Trim Tab

b. Rudder trim tab

(1) Location: lower trailing edge of rudder

(2) Function: provides pressure relief for rudder pedals

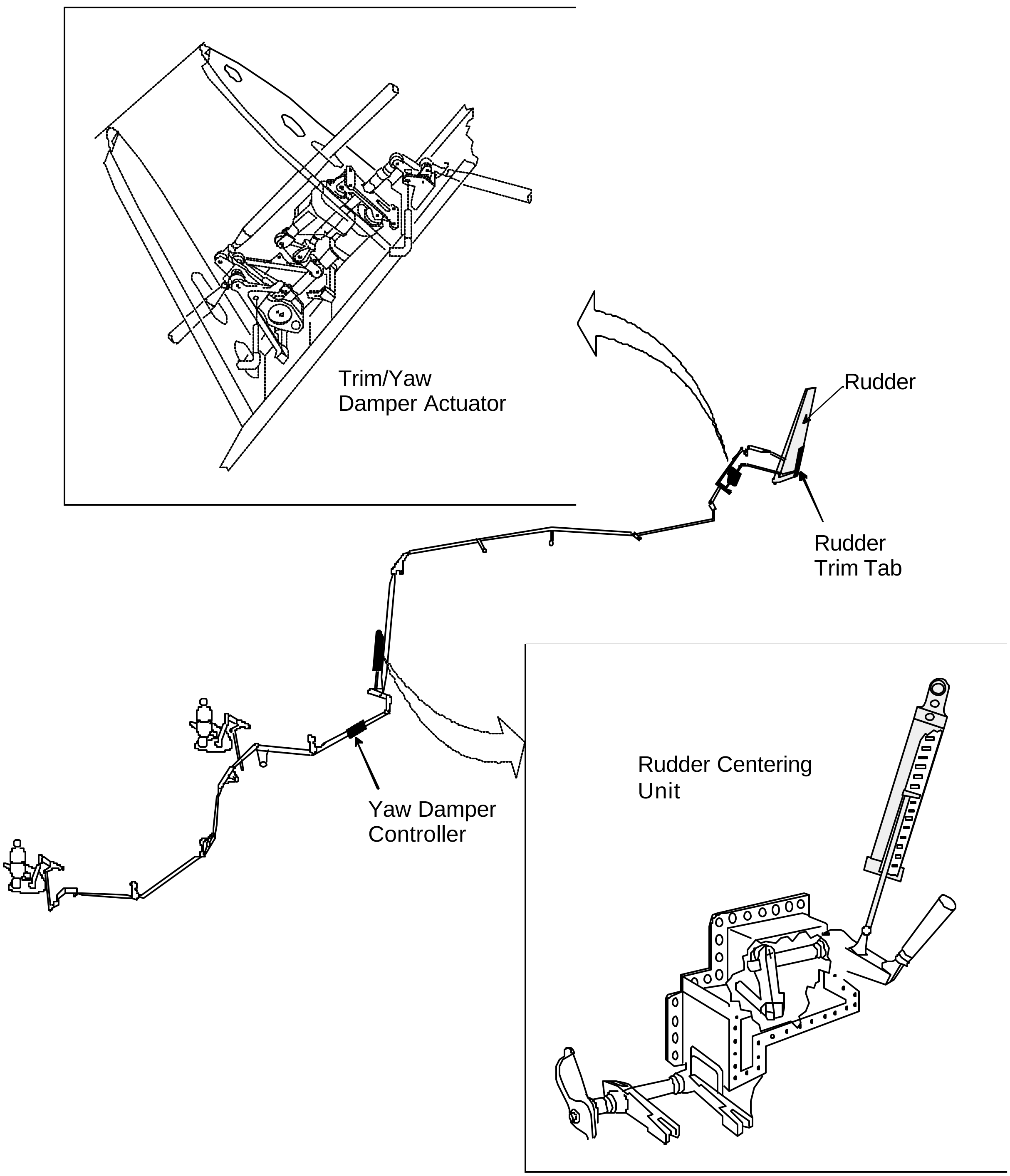


Figure 8: FLIGHT CONTROLS--RUDDER SYSTEM COMPONENTS

(3) Max deflection of 6 degrees +/- 1 degree below 217 IAS. 1.3 degrees +/- .6 degree at 450 IAS

Overlay 3
Trim/Yaw Damper Actuator

c. Trim/Yaw damper actuator

(1) Location: inside fuselage, at root of vertical stabilizer

(2) Function: electromechanical device moves rudder trim tab upon input from trim switch or automatically through the yaw damper controller (computer) when the rudder is moved

Overlay 4
Rudder/Yaw Damper Linkage

d. Rudder/Yaw damper actuator linkage

(1) Location: Below YDA at root of vertical stabilizer

(2) Function: mechanical linkage moves rudder and rudder trim tab through the automatic feature of the YDC

Overlay 5
Rudder Centering Unit

e. Rudder centering unit

(1) Location: on aft face of aft seat frame

(2) Function: produces light feel force (resistance) during low-speed flight and on deck for rudder centering

f. Rudder pedal shaker

(1) Location: attached to left rudder pedal in forward cockpit

(2) Function: activated by AOA system. Provides stall warning, along with a stall warning tone when AOA is 21.5 units or greater

Sg 2, fr 26
(5 Overlays)
Fig 9: *Rudder Controls/Indicators*

2. Cockpit controls/switches/indicators

a. Rudder pedals

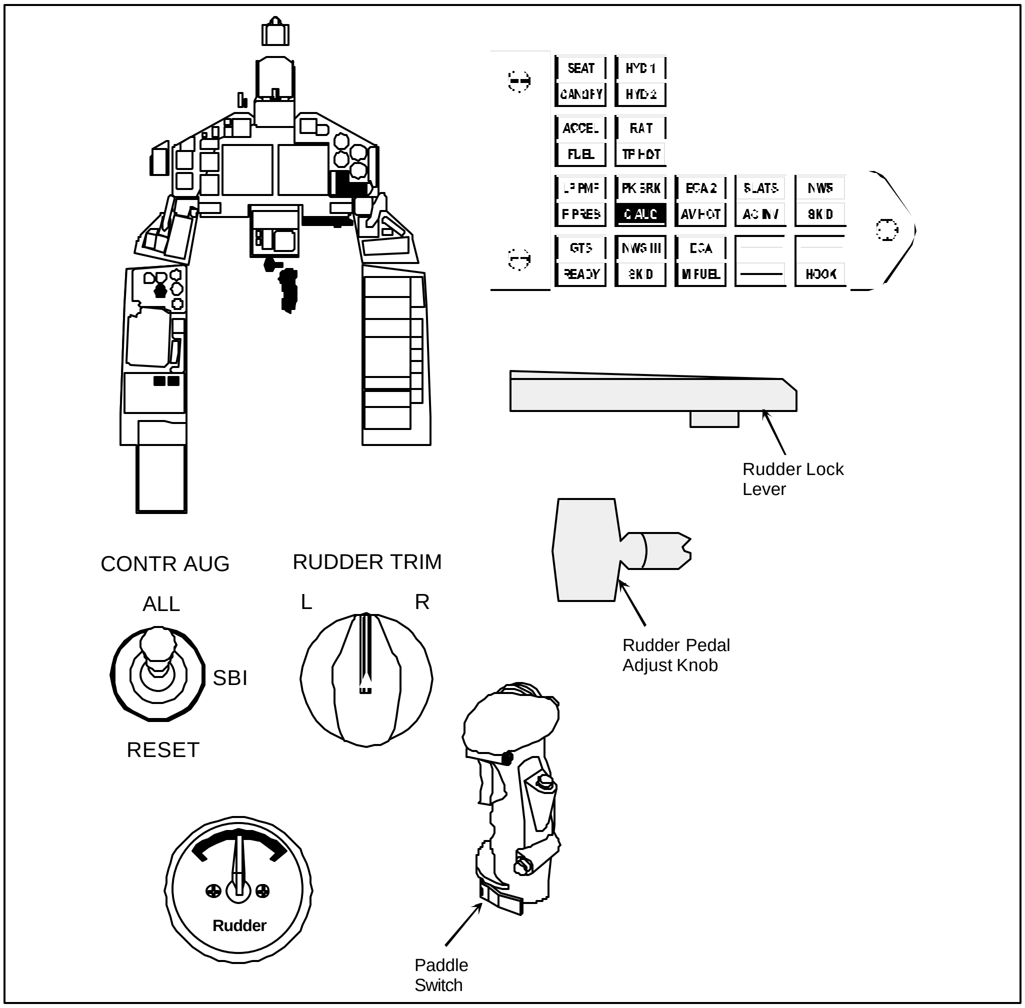


Figure 9: RUDDER CONTROLS/INDICATORS

(1) Adjustable via rudder pedal adjust knob, just forward of stick in both cockpits

2) Toe pedals independently operate hydraulic wheel brakes

b. RUDDER trim indicator

(1) Location: left console forward of throttle quadrant, below AILERON trim indicator in both cockpits

Overlay 1
Rudder Trim Control

(2) Function: displays position of rudder trim

c. RUDDER TRIM knob

(1) Location: on left console, directly adjacent to STBY STAB TRIM switch in both cockpits

(2) Function: three-position switch, spring loaded to center activates rudder trim actuator

(3) Rudder trim is not available with CONTR AUG BIT in progress

Overlay 2
C AUG Caution Light

d. C AUG caution light

(1) Location: on caution advisory panel in both cockpits

(2) Function: illuminates when control augmentation is off, degraded, or indicates BIT in progress

Overlay 3
Rudder Pedal Adjust Knob

e. RUDDER PEDAL ADJUST knob

(1) Location: panel assembly attached to control support struts, forward of control stick in both cockpits

(2) Function: adjusts pedals to accommodate leg reach

Overlay 4
CONTR AUG Switch

f. CONTR AUG switch

(1) Location: adjacent to RUDDER TRIM control on left console FWD cockpit

(2) Function: three-position switch

(a) ALL--provides Dutch-roll damping, turn coordination, rudder trim, and speed brake-stabilator interconnect capabilities; also initiates BIT

(b) SBI--provides rudder trim and speed brake-stabilator interconnect capabilities

(c) RESET (momentary, spring loaded to SBI)--resets the system

g. Paddle switch

Overlay 5
Paddle Switch

(1) Location: lower front side of control stick

(2) Function: (momentary switch) deactivates the control augmentation system and the NWS system with landing gear down

LESSON NOTES

Emphasize that the rudder is the only flight control not hydraulically activated and that the rudder gust lock must be engaged when the aircraft is parked.

h. Rudder lock lever

Overlay 6
Rudder Lock Lever

(1) Location: right control unit support strut, fwd cockpit only

(2) Function: locks rudder in neutral position for protection while aircraft is parked

3. Operating characteristics/limitations

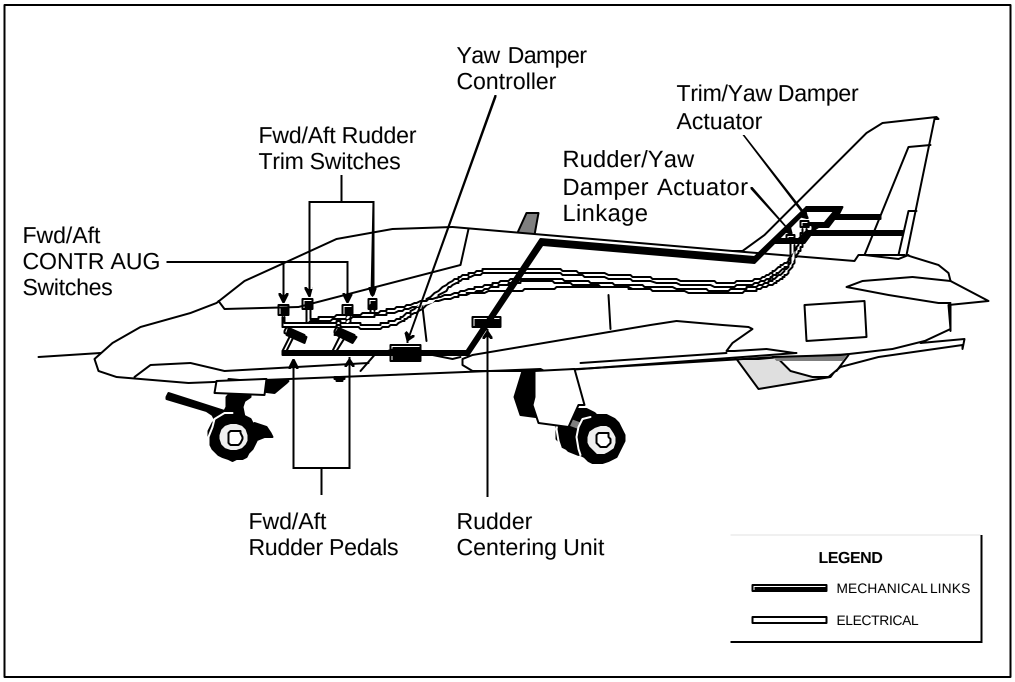


Figure 10: RUDDER SYSTEM COMPONENTS--SIMPLIFIED

Sg 2, fr 33
Fig 10: *Rudder System Components--Simplified*

a. Control augmentation system (CAS)

NOTE: GINA mode manipulation results in yaw damper degradation and a C AUG caution light. A CONTR AUG system reset is required to reestablish control augmentation operation.

(1) SBI and rudder trim available with weight on or off wheels. Aileron-rudder interconnect (ARI) and yaw damping available only with weight off wheels

(2) Yaw damping commands are zero with airspeed above 217 KIAS, except when trimming rudder

(3) SBI system provides stabilator trim inputs to reduce pitch transients during speed brake extension or retraction

(4) CAS BIT can only be initiated with weight on wheels, airspeed less than 80 knots, and FLAPS/SLATS switch UP. C AUG caution light illuminates for approximately 120 seconds and then extinguishes indicating a successful test

WARNING: Initiating the CONTR AUG BIT cycles the rudder trim tab. Ensure the CONTR AUG BIT is complete prior to taxi or takeoff.

b. Yaw damping system and Aileron Rudder Interconnect (ARI) operate automatically with weight off wheels and airspeed less than 217 KIAS

c. Pilot may override yaw damp system by operating rudder pedals

d. Rudder system operates in three modes

(1) Pilot-operated through pedals

(2) Pilot-controlled electric trim actuator

(3) Auto-controlled trim of tab via yaw damper system

e. Rudder deflection maximum: 20 +/- .5 degrees from neutral, including 6 +/- 1 degree max trim (limited by electronic damping system)

f. Rudder lock provides protection from wind up to 70 mph

g. Simultaneous operation of both trim switches in opposite directions disables the trim motor

D. Aircraft interfaces **1.4.14.2**

1. Hydraulic system

   a. Ailerons and stabilator power control units (PCUs) contain tandem actuators which receive hydraulic power from both HYD 1 and HYD 2. Failure of either hydraulic system will not affect flight control operation.

   b. Rudders are mechanically operated

2. Electrical

   a. 28 VDC generator bus powers

      (1) Aileron trim

      (2) Rudder trim

      (3) Standby stabilator trim

      (4) Trim indicator (aileron, rudder, and stabilator)

   b. 28 VDC essential services bus powers , primary stabilator trim only.

E. Summary:

The aileron, stabilator, and rudder systems make up the flight controls. The aileron and stabilator systems are hydraulically operated with redundant actuators. The rudder system is mechanical and should be locked when the aircraft is parked. Toe pedals on the rudder pedals activate the independent hydraulic wheel brakes. All flight controls have trim capability. The control augmentation system enhances the flight characteristics of the aircraft.

III. Flaps/slats, speed brakes

A. Flap system **1.5.4.1.2.1, 1.5.4.1.2.1.2, 1.5.4.1.2.1.1**

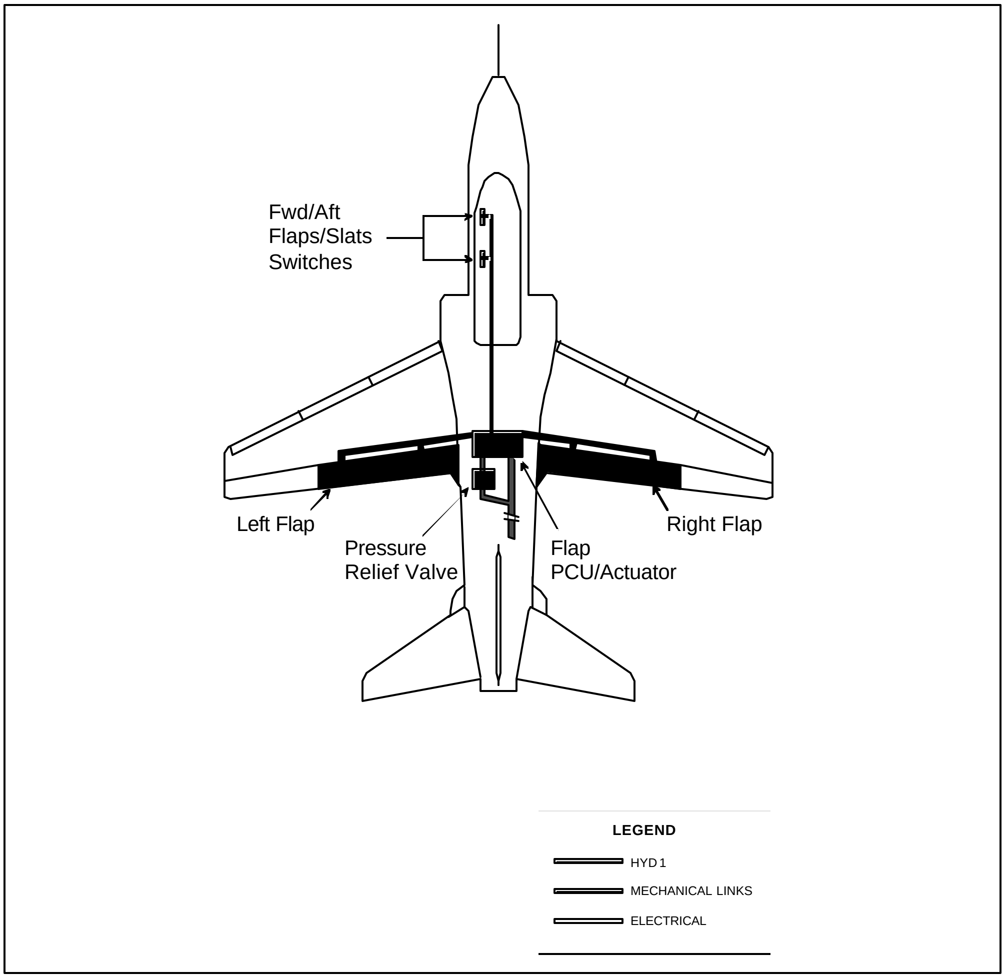


Figure 11: FLAP SYSTEM COMPONENTS--SIMPLIFIED

1. System overview: augments lift to wing, allowing flight operations at lower airspeeds

2. Control surface components

   a. Flap panels

      (1) Location: trailing edge of each wing panel (extending from wing root), inboard of trailing edge of each wing

Sg 3, fr 2
Lesson Organization

FLIGHT CONTROL SYSTEM

* Major component identification
* Flight controls
* Flaps/slats, speed brakes
* Aircraft systems interfaces

Sg 3, fr 3
Fig 11: *Flap System Components--Simplified*

(2) Function: augment lift at low airspeed

b. Flap actuator

(1) Location: one hydraulic actuator bolted onto bracket at aft face of aft wing spar

(2) Function: powered by HYD 1, extends/retracts flaps

c. Pressure/thermal relief valves

(1) Location: incorporated into flap selector valve package right side of aircraft, forward of frame 21

(2) Function

(a) Pressure valve

(i) Directs hydraulic pressure to and from flap actuator

(b) Thermal relief valve

(i) Protects HYD lines from thermal expansion

Sg 3, fr 4 (2 Overlays)
Fig 12: *Flap Controls/Indicators*

3. Cockpit controls/switches/indicators

a. FLAPS/SLATS lever

(1) Location: inboard of the throttle quadrant

(2) Function: three position control with detents for selecting flaps UP, 1/2, or DN. Forward and aft controls are mechanically linked and operate the flap hydraulic valve via a common switch

Overlay 1
EMER FLAPS Switch

b. EMER FLAPS switch

(1) Location: landing gear panel, below emergency gear handle

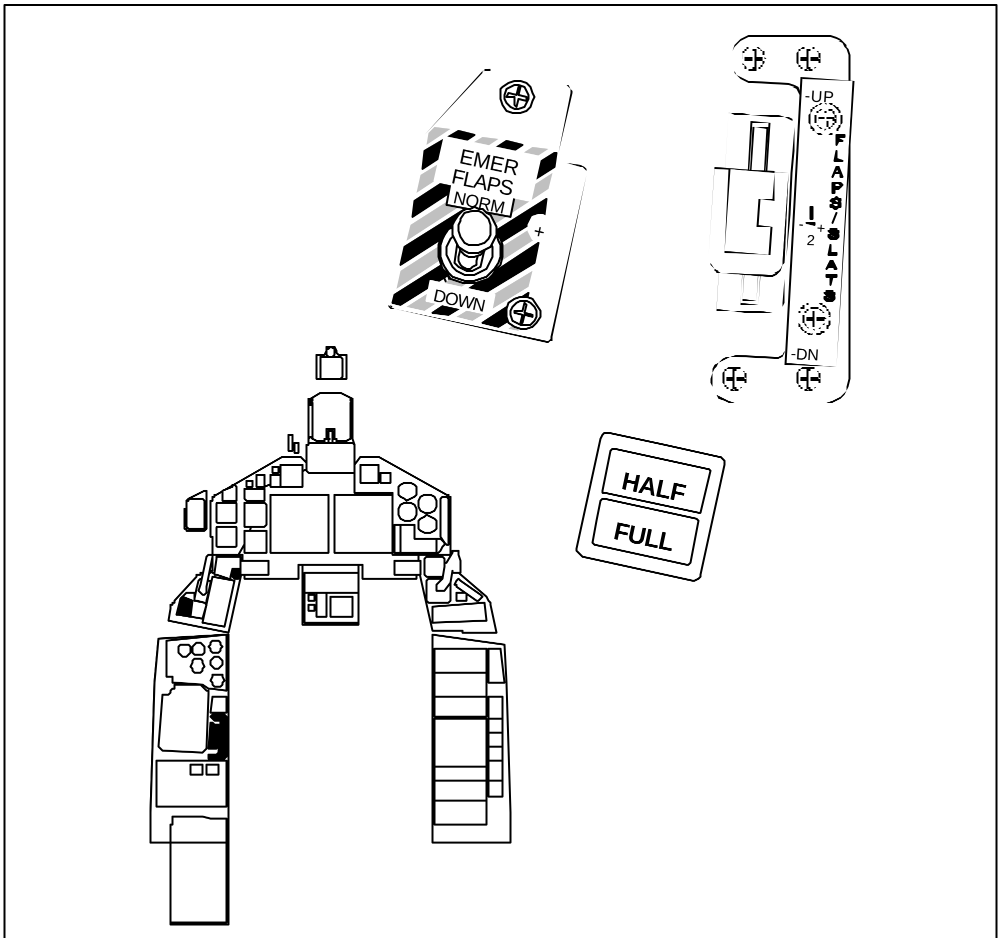


Figure 12: FLAP CONTROLS/INDICATORS

(2) Function: directs pressure from wheel brake/emergency flap accumulator in event of HYD 1 failure to fully extend flaps

c. FLAP position indicator

(1) Location: left instrument panel, to the right of the EMER JETT button

(2) Function: displays flaps as half full

4. Operating characteristics/limitations

a. Flaps raised and lowered via single actuator

b. Powered by HYD 1 via push-pull control rods and bellcrank levers

Overlay 2
FLAP Position Advisory Light

Sg 3, fr 5
Fig 11: *Flap System Components--Simplified*

c. Extension of flaps via wheel brake/emergency flap accumulator in event of HYD 1 failure

d. Full extension of flaps is approximately 50 degrees, half approximately 25 degrees

e. EMER FLAPS switch fully extends flaps if adequate accumulator pressure is available. No flap extension if accumulator pressure is below 2200 psi.

f. Speed restriction for deployment: 200 KIAS

g. Maneuvering envelope with both flaps extended (symmetrical): 0 to +2.0 g max. Maneuvering envelope with a split flap (unsymmetrical) condition: +1.0 to +1.5 g max

NOTE: Due to the design of the T-45 a split flap condition is highly unlikely. Be advised that this is not an impossibility and would be a very dangerous situation should it occur.

B. Slat system **1.5.4.1.2.1, 1.5.4.1.2.1.2, 1.5.4.1.2.1.1**

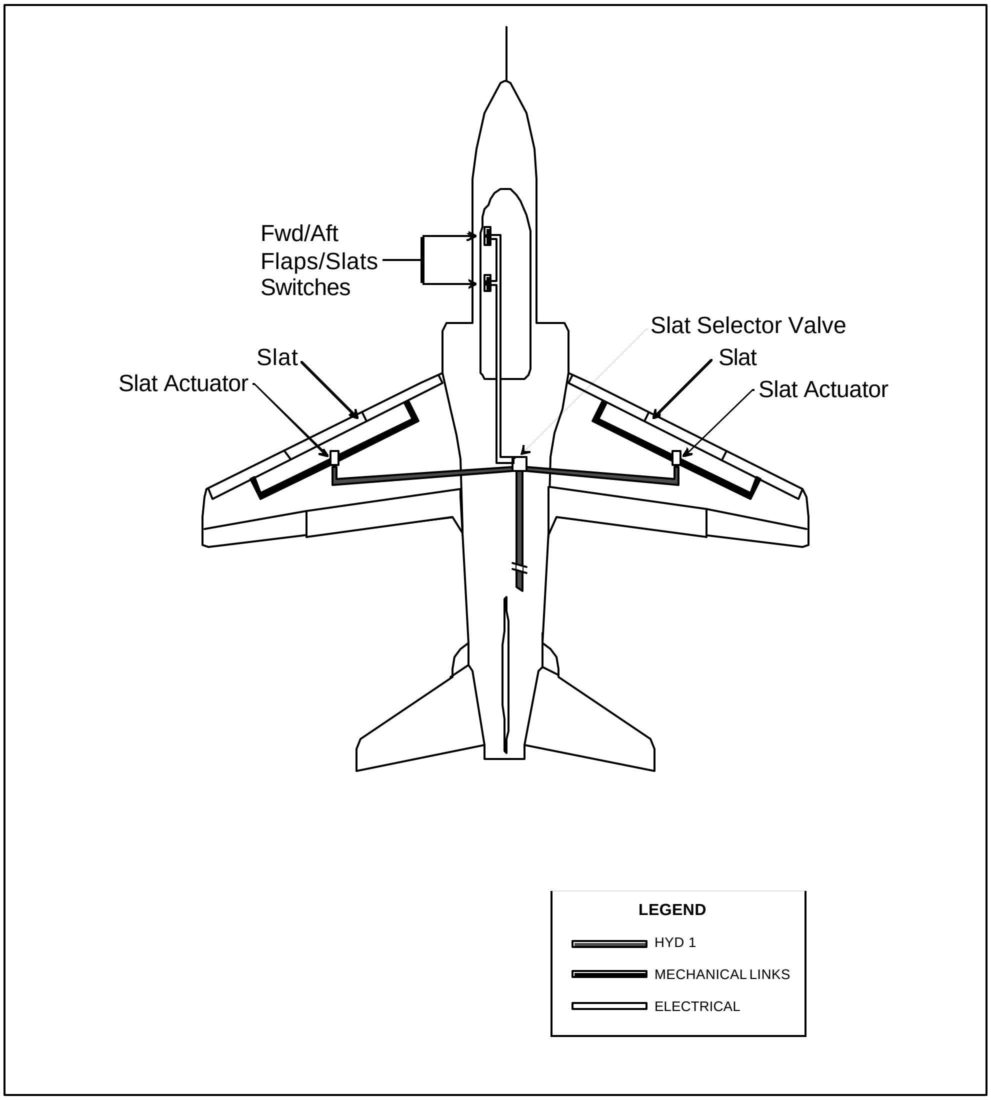


Figure 13: SLAT SYSTEM COMPONENTS--SIMPLIFIED

Sg 3, fr 6
Fig 13: *Slat System Components--Simplified*

1. System overview: augments lift to wing when extended, decreasing stall speed and increasing aircraft control and stability during slow speed flight

2. Control surface components

   a. Slats

      (1) Location: leading edge of each wing extending from wing root to near wingtip

(2) Function: improve stall margin and slow speed flight characteristics

b. Slat actuators

(1) Location: one actuator attached to front spar of each wing

(2) Function

(a) Powered by HYD 1, extends/retracts slats by mechanical linkage

(b) Normal operation of actuators maintains slat symmetry during extension/retraction

(c) Synchro cable between actuators will maintain slats within 2 degrees of each other if normal system fails

c. Thermal relief valves

(1) Location: incorporated into slat selector assembly

(2) Function

(a) Protects hydraulic lines against thermal expansion of hydraulic fluid

3. Cockpit controls/switches/indicators

Sg 3, fr 7
Fig 14: *Slat Controls and Indicators*

a. FLAPS/SLATS lever

(1) Location: inboard of the throttle quadrant

(2) Function: three position control with detents for selecting flaps/slats UP, 1/2, or DN. Forward and aft controls are mechanically linked and operate the flap hydraulic valve via a common switch

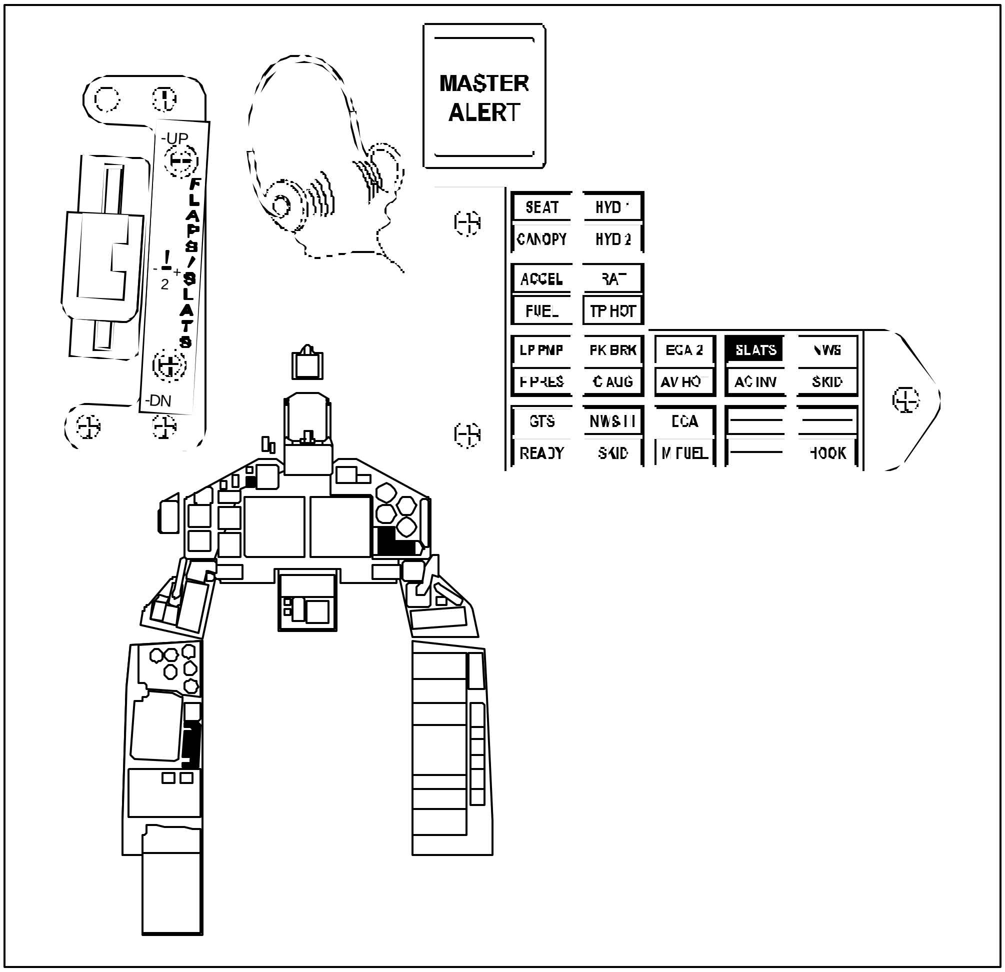


Figure 14: SLAT CONTROLS AND INDICATORS

(a) UP: slats retracted

(b) 1/2 or DN: slats extended

b. SLATS caution light

(1) Location: caution advisory panel

(2) Function: illuminated when

(a) Slats not in selected position or split slats

Sg 3, fr 8
Fig 13: *Slat System Components--Simplified*

(b) Slats extended and airspeed increases above 217 KIAS

(c) Slats selected when airspeed is above 217 KIAS (slats will not extend)

4. Operating characteristics/limitations

a. Slats divided into three segments per side that are interconnected so they don't transmit wing loads

b. Slats raised and lowered by HYD 1 powered actuator in each wing that drive rods linked to the inner and outer slat segments, the center section is attached to and moves simultaneously with the two outer sections

c. No system to extend slats with HYD 1 failure

d. Full extension of slats is 15 degrees

e. Speed restriction for deployment: 200 KIAS

NOTE: There is no blow back feature in the slat hydraulic system.

f. Maneuvering envelope with both slats extended (symmetrical condition): 0 to +2.0 g max. Maneuvering envelope with a split slats (unsymmetrical condition): +1.0 to +1.5 g max

NOTE: Due to the design of the T-45 a split slat condition is highly unlikely. Be advised that this is not an impossibility and would be a very dangerous situation should it occur.

C. Speed brake system **1.4.19.3.1, 1.4.19.2.1, 1.4.19.3**

LESSON NOTES

Provide examples of different flight conditions, explain how speed brake positioning will affect the aircraft.

1. Components

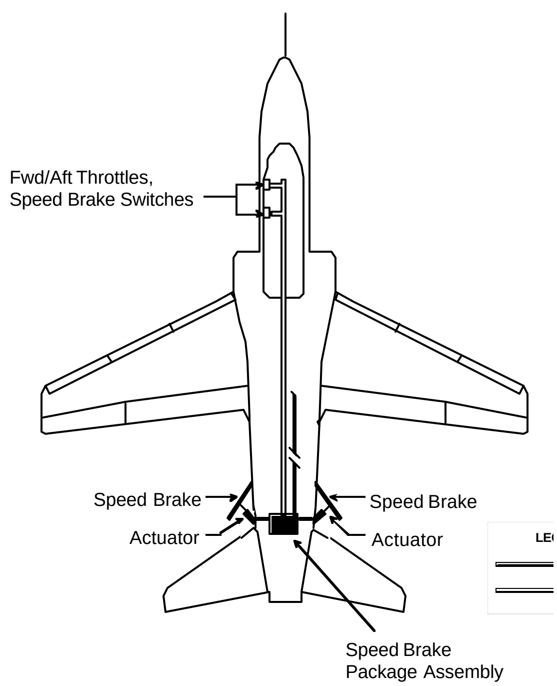


Figure 15: SPEED BRAKE SYSTEM COMPONENTS--SIMPLIFIED

Sg 3, fr 9
Fig 15: *Speed Brake System Components--Simplified*

a. Left/right speed brakes

(1) Location: one speed brake panel on each side of aft fuselage

(2) Function: increase drag, decrease speed for maneuvering when needed

NOTE: The use of speed brakes during approach allows the engine to be spooled up without an increase in airspeed.

b. Hydraulic actuator

(1) Location: attached to each speed brake door and anchored inside fuselage

(2) Function: extends or retracts speed brakes depending on position of a hydraulically operated slide valve

2. Cockpit controls/switches/indicators

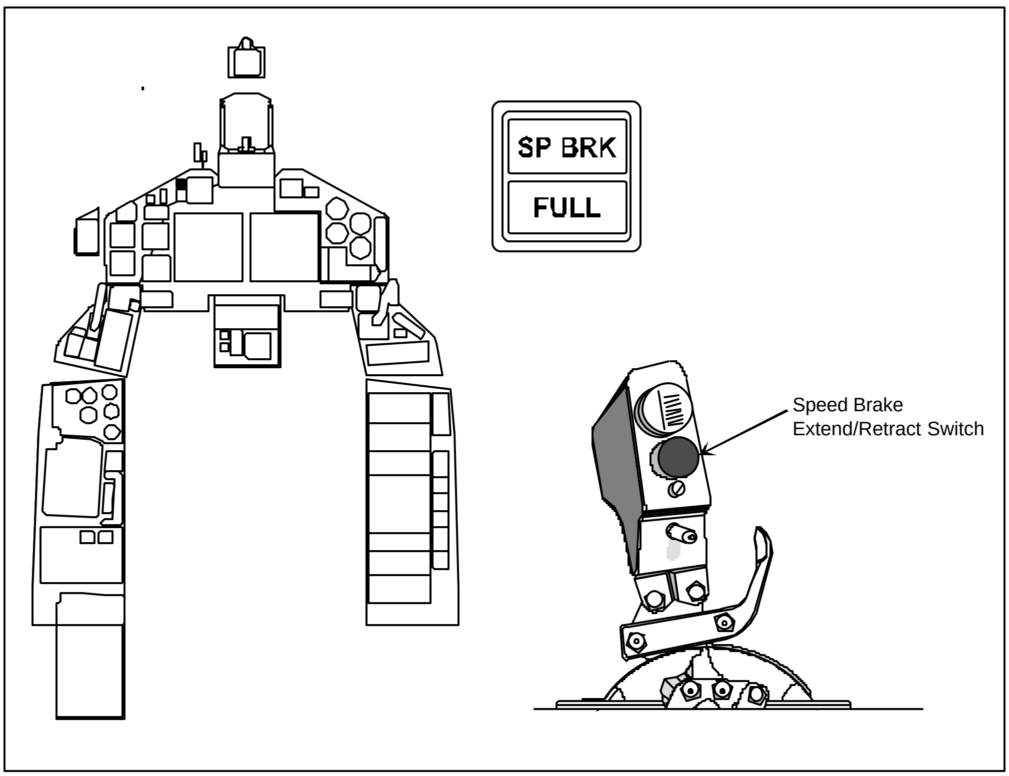


Figure 16: SPEED BRAKE CONTROLS/INDICATORS

a. SP BRK advisory light

(1) Location: on upper left instrument panel in both cockpits

Sg 3, fr 10 (1 Overlay)
Fig 16: *Speed Brake Controls/Indicators*

(2) Function: illuminates to indicate speed brakes not fully retracted

b. FULL advisory light

(1) Location: on upper left instrument panel in both cockpits

(2) Function: illuminates to indicate speed brakes are fully extended

c. Extend/Retract switch

Overlay 1
Extend/Retract Switch

(1) Location: on throttle grip under COMM switch

(2) Function: three-position switch

(a) Forward (momentary)—retracts speed brakes. Released, switch returns to center position

(b) Center—speed brakes remain in selected position

(c) Aft—holding switch in this position extends the speed brakes, as long as the switch is held, until full extension (60 degrees). Released, switch returns to center position.

NOTE: Extension of the speed brakes (moving the switch aft) can occur incrementally. However, the speed brakes will fully retract when the speed brake switch is moved to the forward position.

Sg 3, fr 11
Fig 15: *Speed Brake System Components--Simplified*

3. Operating characteristics/limitations

a. Speed brakes blow back from full extension (60 degrees) at speeds in excess of 380 KIAS

b. Speed brakes may not fully extend above 340 KIAS

c. Pressure and thermal relief valves protect system from excessive air loads and pressure buildup due to heat

d. Speed brake advisory light is illuminated anytime the speed brakes are not fully retracted

e. Cockpit selecting RETRACT overrides cockpit selecting EXTEND

f. No redundant system for speed brakes in event of HYD 1 failure

D. Summary:

The flap/slat and speed brake systems are hydraulically operated. The speed brakes have a blow-back feature. The flaps have three positions, UP, 1/2, and DN. The slats are retracted when the FLAPS/SLATS switch is set to UP and extend when the FLAPS/SLATS switch is set to 1/2 or DN

PROGRESS CHECK

Question 1 — 1.5.4.1.2.1
Flap/slat extension should only be selected at less than _____ KIAS.

ANSWER: 200

Sg 4, fr 2
Lesson Organization

FLIGHT CONTROL SYSTEM

* Major component identification
* Flight controls
* Flaps/slats, speed brakes
* Aircraft system interfaces

IV. Aircraft systems interfaces **1.4.14.2, 1.5.4.1.2.1.5, 1.4.19.2**

Sg 4, fr 3
***Fig 17:** Flap System Components*

A. Flaps/slats

1. Hydraulic

a. Powered by the HYD 1 system

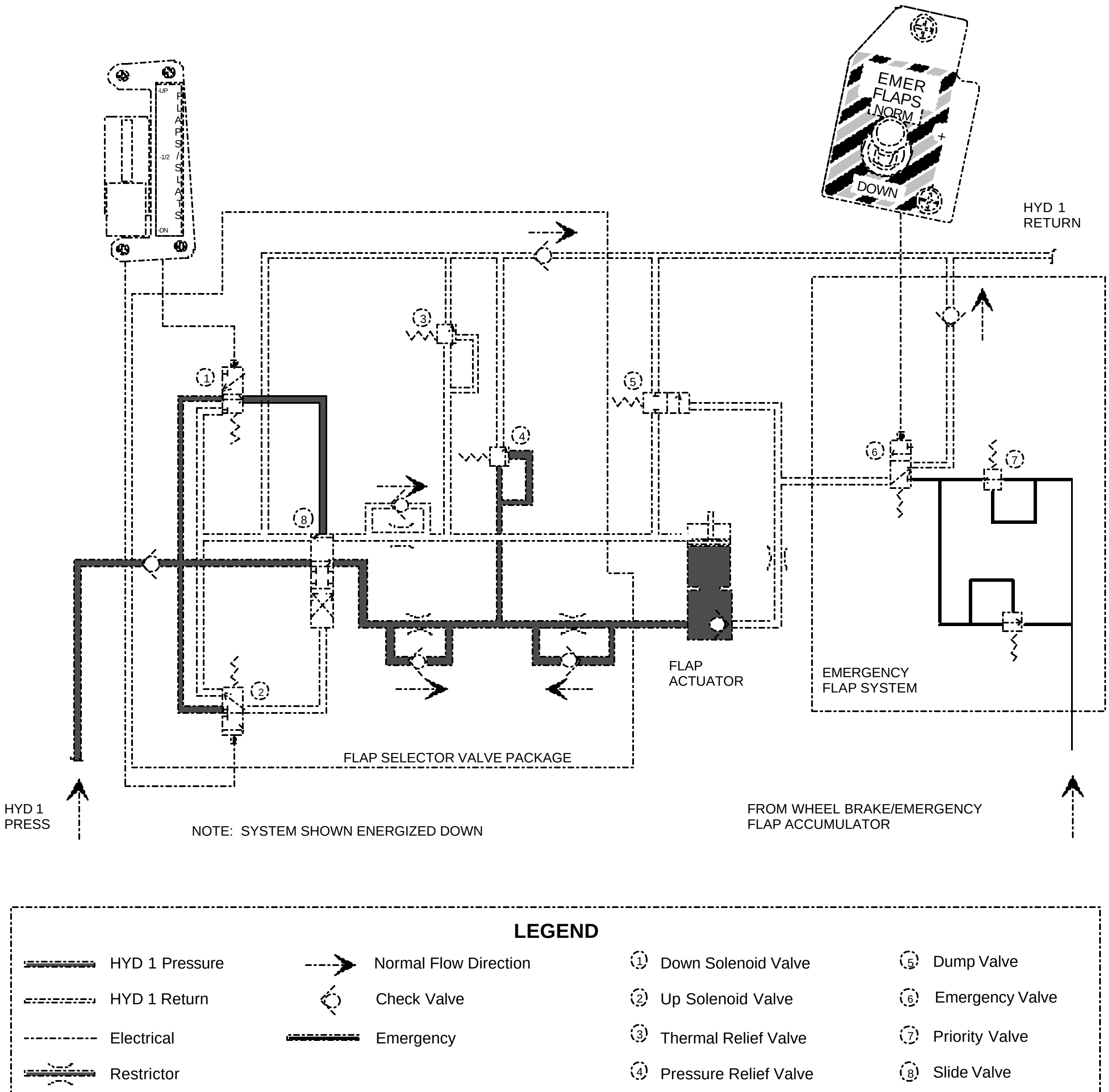


Figure 17: FLAP SYSTEM COMPONENTS

_Sg 4, fr 4_
Fig 18: *Slat System Components*

b. Should HYD 1 fail, backup power for flaps extension only is provided by the wheel brake/ emergency flap accumulator

NOTE: Slats are hydraulic and function in consonance with the flaps actuation when HYD 1 system pressure is available. No emergency slat extension.

2. Electrical: 28 VDC essential services bus powers both normal and emergency flap operation

_Sg 4, fr 5_
Fig 19: *Speed Brake System Components*

B. Speed brakes 1.4.1.9.2

1. Hydraulic

a. Powered by HYD 1 system only

b. No redundant or emergency backup system

2. Electrical: 28 VDC essential services bus powers speed brake selection

_Sg 4, fr 6_
Fig 20: *Hydraulic System Block Diagram*

C. Hydraulic system

1. Ailerons and stabilator are tandem actuator design—failure of either hydraulic system does not affect operation

2. Flaps interface with HYD 1 only—wheel brake/ emergency flap accumulator provides backup power in event of failure

3. Slats interface with HYD 1 only--there is no backup power in the event of failure

4. Speed brake system has no redundancy

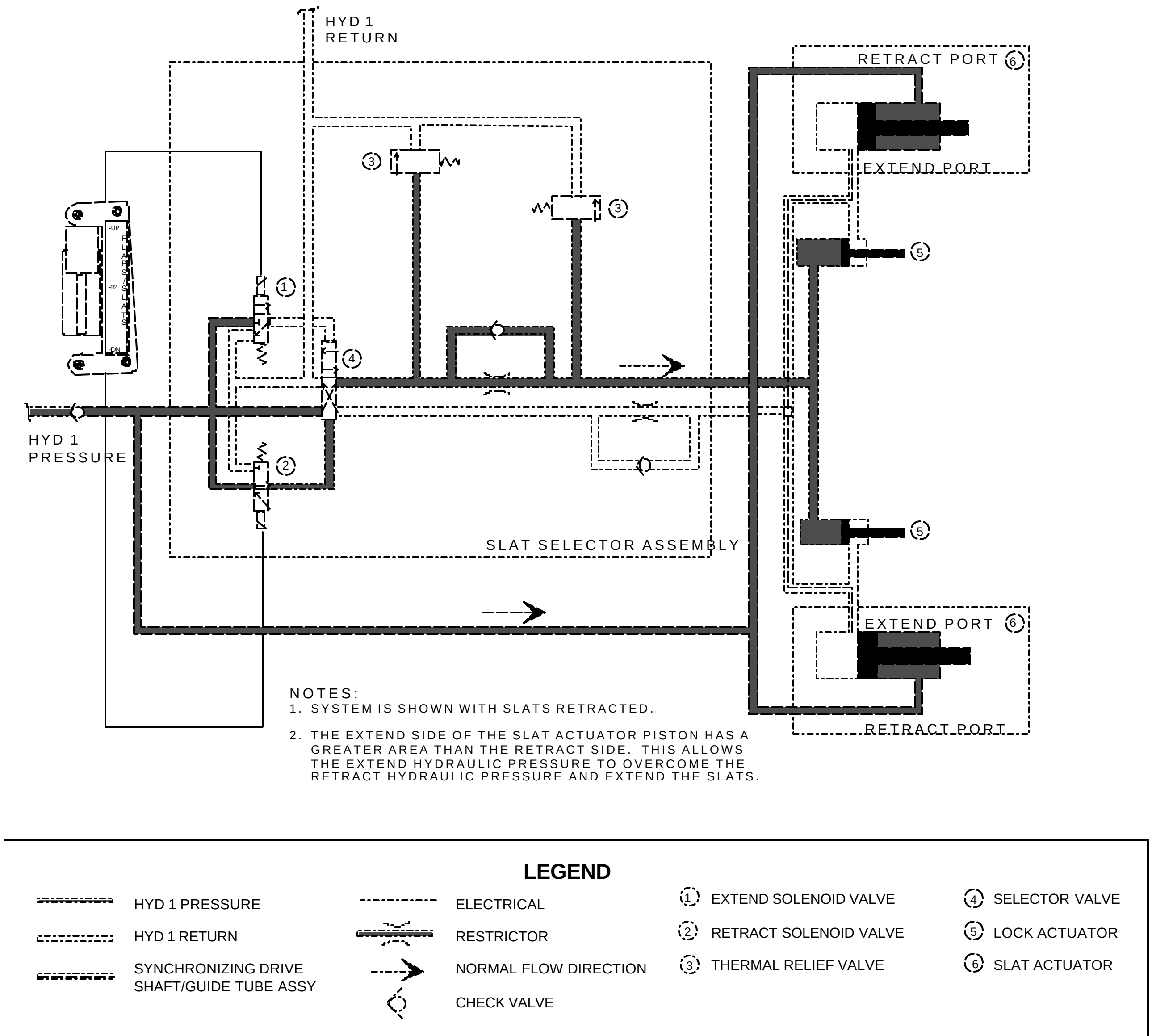
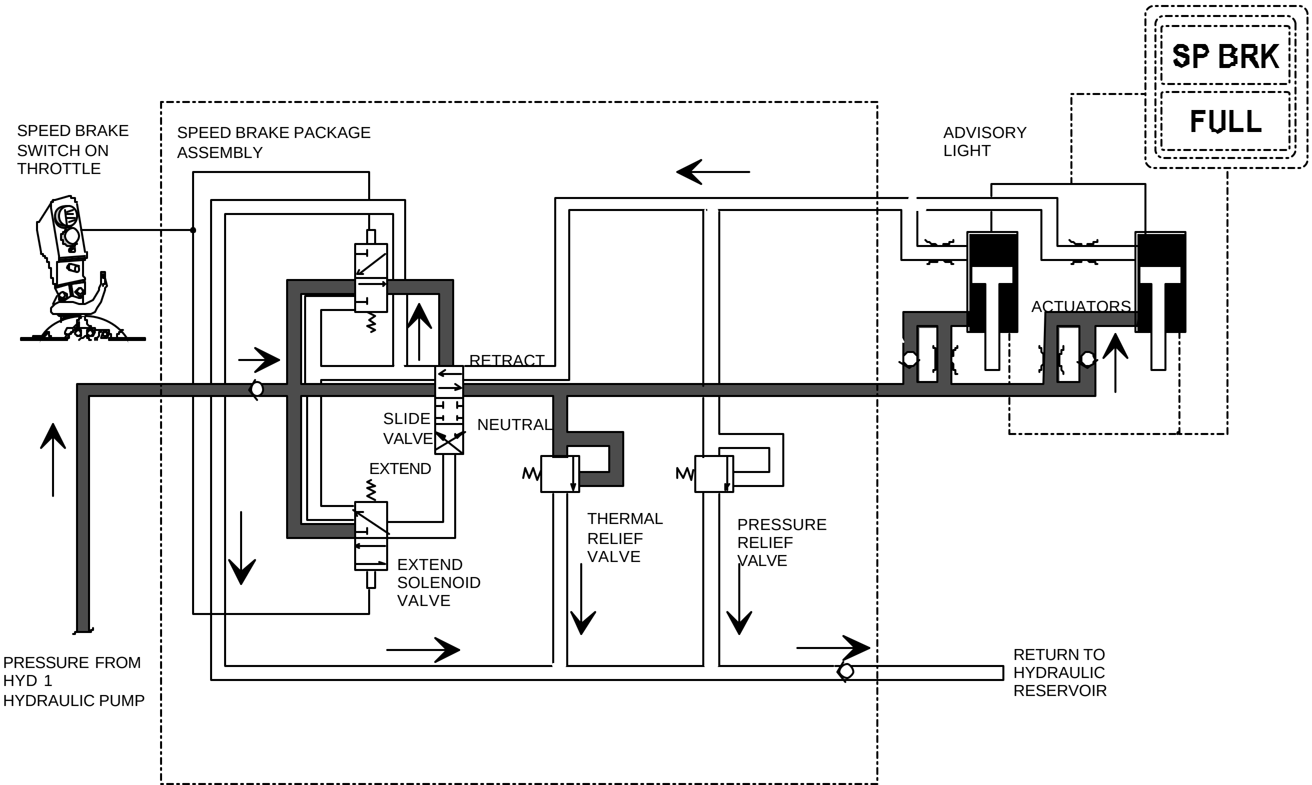


Figure 18: SLAT SYSTEM COMPONENTS



NOTE:

SYSTEM IS SHOWN ENERGIZED SPEED BRAKES RETRACTED.

LEGEND

HYD 1 PRESSURE	ELECTRICAL
HYD 1 RETURN	RESTRICTOR
CHECK VALVE	NORMAL FLOW DIRECTION

Figure 19: SPEED BRAKE SYSTEM COMPONENTS

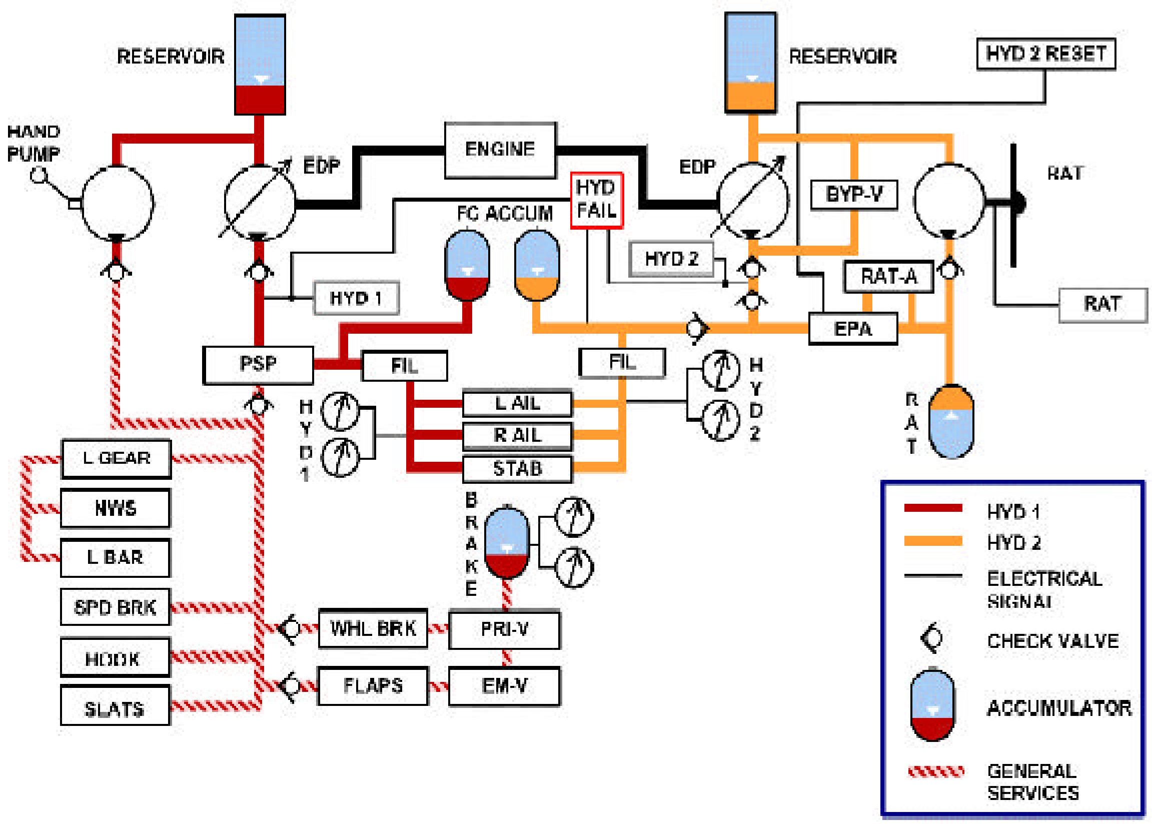


Figure 20: HYDRAULIC SYSTEM BLOCK DIAGRAM

D. Electrical system

1. 28 VDC generator bus powers

   a. Aileron trim

   b. Rudder trim

   c. Trim indicators and stabilator position indicators

   d. Standby stabilator trim

2. 28 VDC essential services bus powers

   a. Primary stab trim

   b. Flaps/slats

   c. Emergency flaps

   d. Speed brakes

PROGRESS CHECK

Question 2 — 1.4.19.2.1
If HYD 1 has failed, which flight control(s) will <u>not</u> remain operative?

ANSWER: Speed brakes, slats

SUMMARY

Sg 6, fr 1
Review Menu

This lesson has presented the major components, physical characteristics, functional descriptions, and operation limitations of the flight control system.

The flight controls consist of ailerons to control roll, stabilator to control pitch, and rudder to control yaw. The control augmentation system enhances flight characteristics and compensates for pitch transients during speed brake operation. The T-45C also employs flaps and slats to increase lift and speed brakes to increase drag. All flight controls except the rudder are hydraulically operated. The rudder is a mechanical system and should be secured with the gust lock lever when the aircraft is parked.

The flight control system controls and indicators consist of the following: aileron/stabilator trim switch, AILERON trim indicator, STBY STAB TRIM switch, STABILATOR position indicator, rudder pedals, RUDDER trim indicator, RUDDER TRIM control, C AUG caution light, RUDDER PEDAL ADJUST knob, CONTR AUG switch, FLAPS/SLATS switch, EMER FLAPS switch, FLAP position advisory light, SLATS caution light, SP BRK and FULL advisory lights, extend/retract switch.

The flaps/slats should not be lowered above 200 KIAS.

CONCLUSION

Because knowledge of the aircraft and its systems directly affects flight safety, your understanding of this system is imperative.

NOTES

LESSON GUIDE

COURSE/STAGE: TS, ADV & IUT / Engineering

LESSON TITLE: Flight Control System Malfunctions

LESSON IDENTIFIER: T-45C TS, ADV & IUT ENG-14

LEARNING ENVIRONMENT: CAI

ALLOTTED LESSON TIME: .7 hr

TRAINING AIDS:

* Figures:
  Fig 1: Flap System Operation
  Fig 2: Slat System Operation
  Fig 3: Stabilator Trim Operation
  Fig 4: Speed Brake Operation
  Fig 5: Aileron Trim Operation
  Fig 6: Rudder Trim Operation
  Fig 7: Summary

STUDY RESOURCES:

* T-45C NATOPS Flight Manual, A1-T45AC-NFM-000
* T-45C NATOPS Pilot's Pocket Checklist, A1-T45AC-NFM-500

LESSON PREPARATION:

Read:

* Part I, Chapter 2.6, "Flight Controls and Trim Systems," and Chapter 2.7, "FLAP/SLAT System" in the T-45C NATOPS Flight Manual, A1-T45AC-NFM-000

Review:

* Lecture Guide for Eng-13, "Flight Control System"

REINFORCEMENT: N/A

LESSON EXAMINATION:

Student is required to read flight control system malfunction paragraphs in the NATOPS Flight Manual, receive classroom instruction, and complete assigned CAI lesson(s). The student shall demonstrate knowledge by completing, from memory with 80% accuracy, true/false and multiple-choice block examinations. The objectives in this lesson will be tested in either Engineering 29X or Engineering 30X.

LESSON OBJECTIVES

1.8.1.6.13.1
Identify indications of split flaps

1.8.1.6.14.1
Identify indications of split slats

1.8.1.6.5.1
Identify indications of runaway stabilator trim (up or down)

1.8.1.6.8.1
Identify indications of speed brake failure

1.8.1.6.6.1
Identify indications of runaway aileron trim

1.8.1.6.1.1
Identify indications of runaway rudder trim

1.8.1.6.3.1
Recall rudder hardover condition

MOTIVATION

During this lesson you will learn to recognize T-45C flight control malfunctions. Each malfunction is presented singularly, but the possibility always exists that more than one of these malfunctions could occur at the same time. Additionally, some malfunctions may closely resemble each other. For example, both a split flap/slat and a runaway aileron trim cause the aircraft to roll. During the Emergency Flight Procedures lessons you will learn the correct procedures to take in response to the malfunctions taught in this lesson.

OVERVIEW

The goal of the flight controls malfunction lesson is to give you the background not only to recognize malfunctions but to evaluate the seriousness of each.

This lesson presents cockpit indications of the following conditions:

* Split flaps/slats
* Runaway stabilator trim
* Speed brake failure
  - Stuck open
  - Stuck closed
* Runaway aileron trim
* Runaway rudder trim
* Rudder hardover condition

REFRESHER

* Recall the location and function of the T-45C flight controls--ailerons, flaps, slats, stabilator, rudder, and speed brakes.

PRESENTATION

I. Split flaps/slats **1.8.1.6.13.1, 1.8.1.6.14.1**

__Fig 1:__ Flap System Operation

A. Indications:

1. Aircraft rolls and yaws after flaps are lowered or raised

2. FLAPS/SLATS lever and FLAP position indicator may not match or SLATS caution light illuminated

__Fig 2:__ Slat System Operation

B. Verifications: roll stops when FLAPS/SLATS lever is returned to previous setting

C. Effects on flight safety: split flaps/slats cause a serious control problem

II. Runaway stabilator trim (up or down) **1.8.1.6.5.1**

A. Indications

__Fig 3:__ Stabilator Trim Operation

1. Aircraft pitches up/down without control stick input by pilot

2. Increasing noseup/nosedown stick forces

3. Aircraft does not respond to stabilator trim inputs

B. Verifications: verifications same as indications

C. Effects on flight safety

1. Runaway stabilator control results in controllable stick forces; however, flight conditions will dictate severity of problem

2. Sustained stick pressure required to maintain control may cause pilot fatigue

III. Speed brake failure **1.8.1.6.8.1**

A. Stuck open

__Fig 4:__ Speed Brake Operation

1. Indications

a. Lack of aircraft acceleration upon application of power

b. Excessive power required to maintain airspeed

c. Continued vibration/airframe buffeting

2. Verifications

   a. SP BRK and FULL advisory lights remain illuminated after RETRACT is commanded

   b. Visual confirmation

3. Effects on flight safety

   a. Increased fuel consumption

   b. Slower aircraft acceleration due to increased drag

B. Stuck closed

1. Indications

   a. Lack of aircraft deceleration upon selection of EXTEND

   b. Lack of expected vibration/airframe buffeting

2. Verifications

   a. SP BRK advisory light <u>not</u> illuminated after EXTEND is commanded

   b. Visual confirmation

3. Effects on flight safety

   a. Loss of ability to increase drag, requiring different power management on landing approach

   b. Engine will be operated at lower power setting—resulting in longer spool-up time when increased power setting is commanded

Fig 5: *Aileron Trim Operation*

IV. Runaway aileron trim **1.8.1.6.6.1**

A. Indications

1. Uncommanded left or right roll

2. Failure to respond to aileron trim inputs

3. Increase in lateral stick pressure

B. Verifications: AILERON trim indicator displays full left or full right trim

C. Effects on flight safety

1. Full runaway trim causes an out-of-trim force easily controlled—no control is lost

2. Sustained stick pressure required to maintain control may cause pilot fatigue

V. Runaway rudder trim **1.8.1.6.1.1**

Fig 6: Rudder Trim Operation

A. Indications

1. Yaw

2. Rudder pedal displacement

3. Yaw-induced roll

4. Failure to respond to trim inputs

B. Verifications

1. RUDDER trim indicator reads full left/right

2. Aircraft yaws (ADI slip indicator off center)

NOTE: The control augmentation system includes both rudder trim and yaw damper systems. A malfunction with either system could cause similar indications. If the yaw damper is enabled and the trim returns to center when it is paddled off, the yaw damper is at fault. If the malfunction continues after the yaw damper is deselected, the trim system is at fault.

C. Effects on flight safety

1. Full runaway rudder trim causes an out-of-trim force that is controllable by applying rudder and aileron and adjusting airspeed as required

2. The continuous application of opposite rudder may cause pilot fatigue

VI. Rudder hardover condition **1.8.1.6.3.1**

A. Indications

1. Severe yaw

2. Yaw-induced roll

3. Rudder pedal fully deflected

B. Verifications

1. Slip indicator off center

2. Visual confirmation by wingman or by looking in rear-view mirrors

C. Effects on flight safety

1. Aircraft instability increases with airspeed

2. Difficulty in maintaining directional control (both in flight and on landing roll-out)

3. You cannot use nose wheel steering (NWS) because it interfaces with the deflected rudder pedal

4. Overriding malfunction (by applying aileron) may cause pilot fatigue

5. Approach/stall speeds will be higher than normal

SUMMARY

This lesson has presented indications of the following flight control malfunctions:

Fig 7: Summary

* Split flaps/slats
* Runaway stabilator trim
* Speed brake failure
    - Stuck open
    - Stuck closed
* Runaway aileron trim
* Runaway rudder trim
* Rudder hardover condition

CONCLUSION

Being able to recognize aircraft flight control malfunctions quickly is critical to making a safe and logical decision in an emergency.

The conditions described in this lesson might occur in conjunction with some malfunction related to another T-45C system.

If this lesson has raised any questions for you, be certain to contact your instructor.

FIGURES

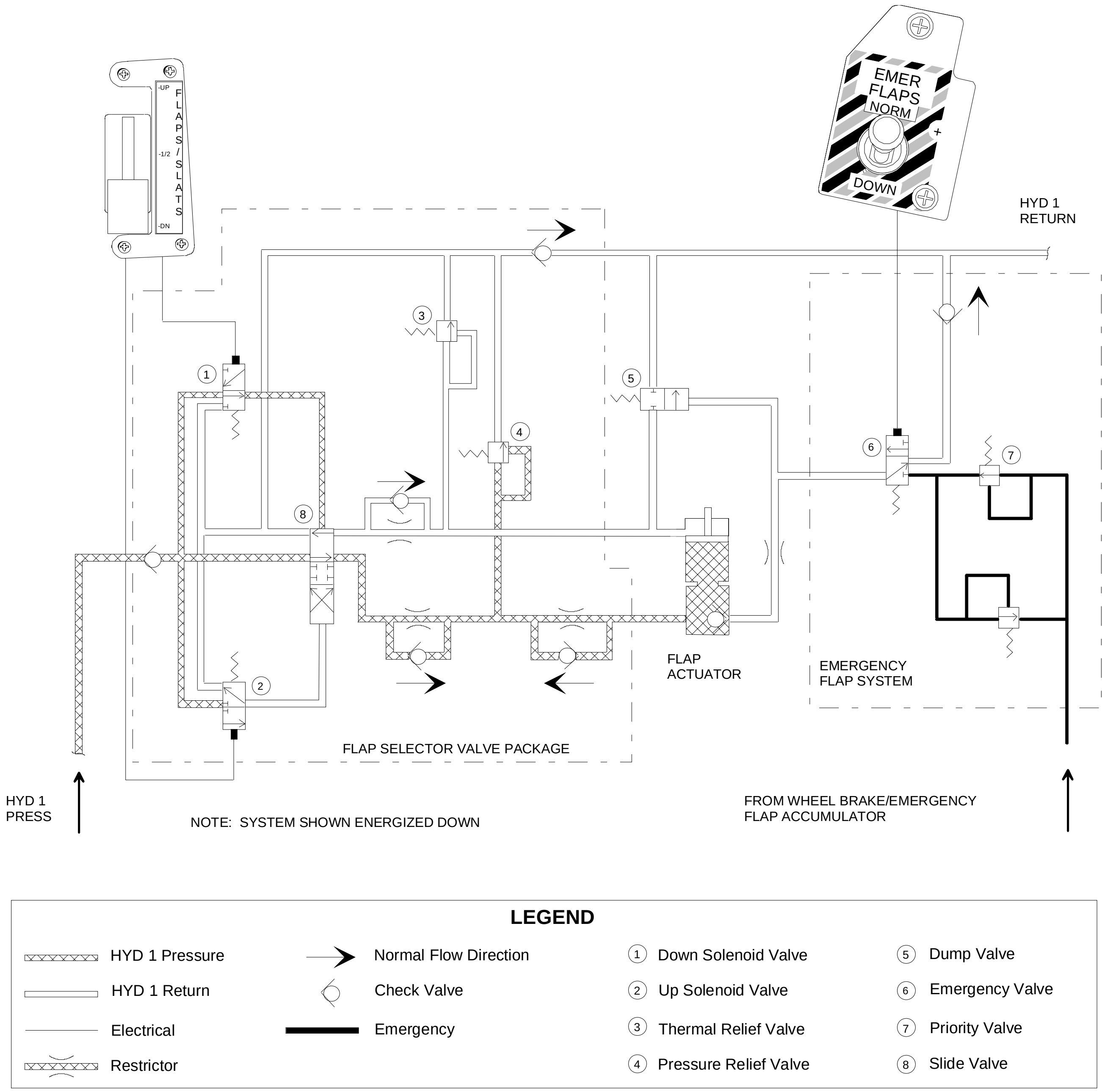


Figure 1: FLAP SYSTEM OPERATION

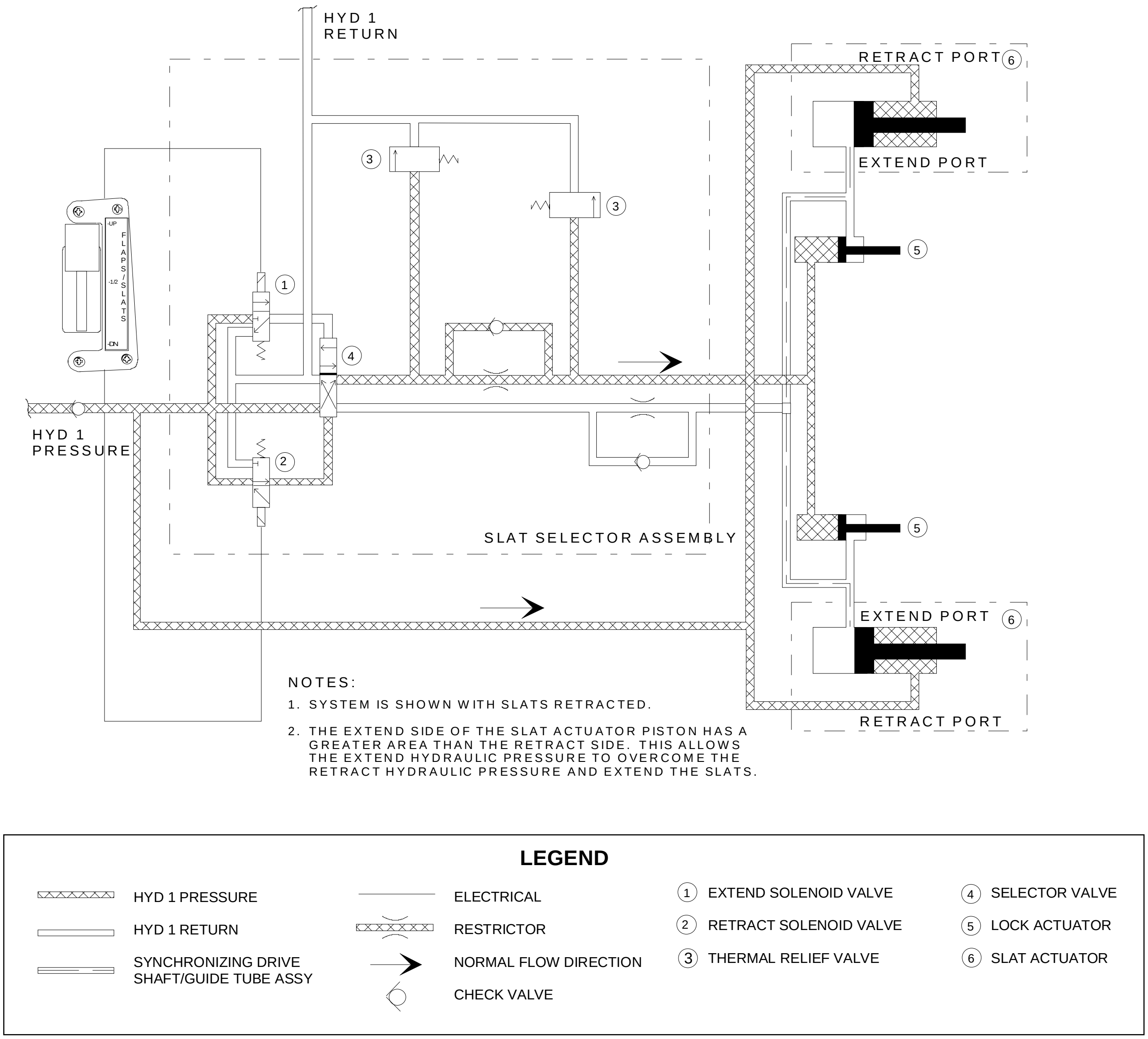


Figure 2: SLAT SYSTEM OPERATION

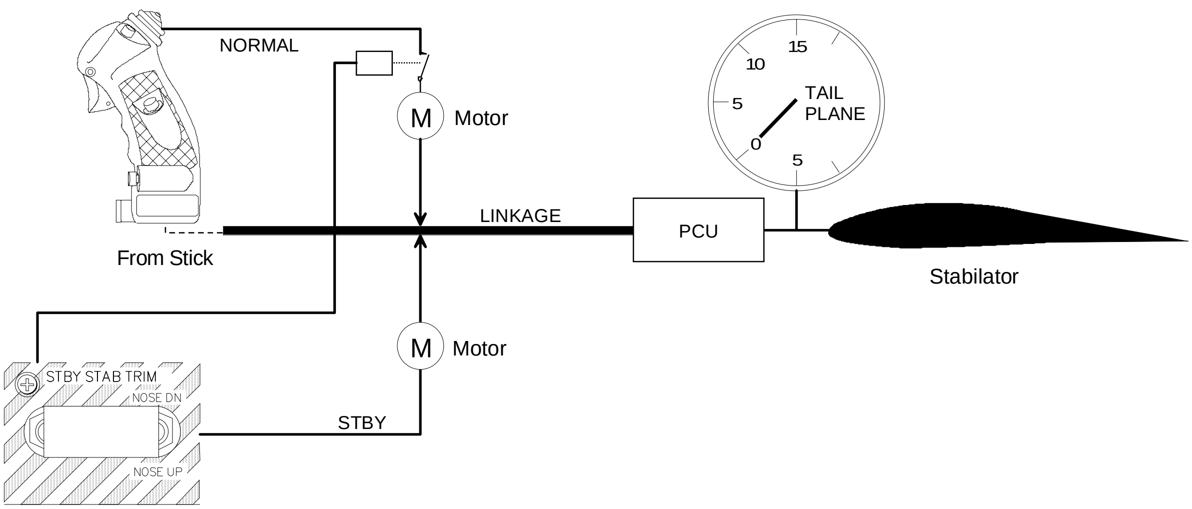


Figure 3: STABILATOR TRIM OPERATION

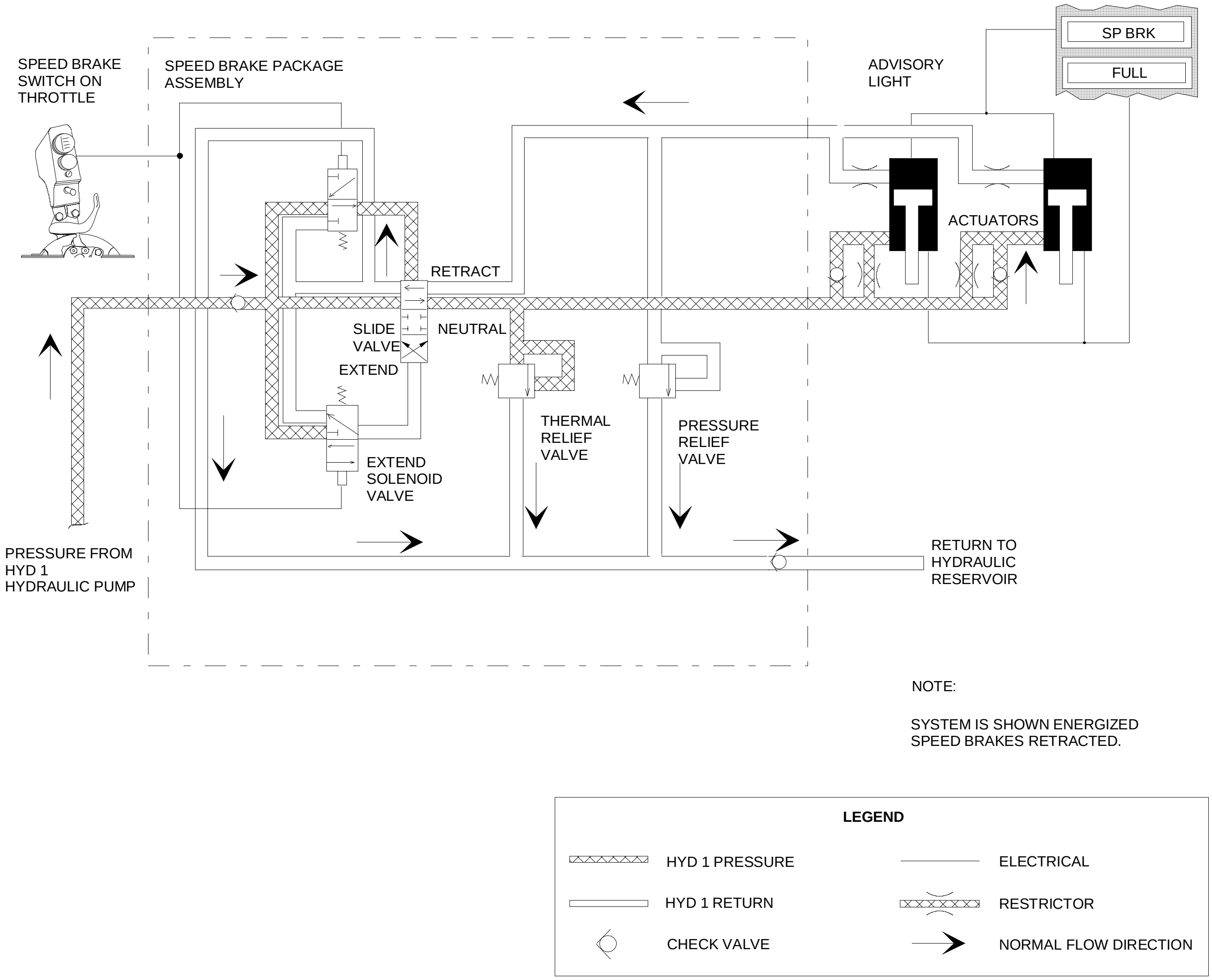


Figure 4: SPEED BRAKE OPERATION

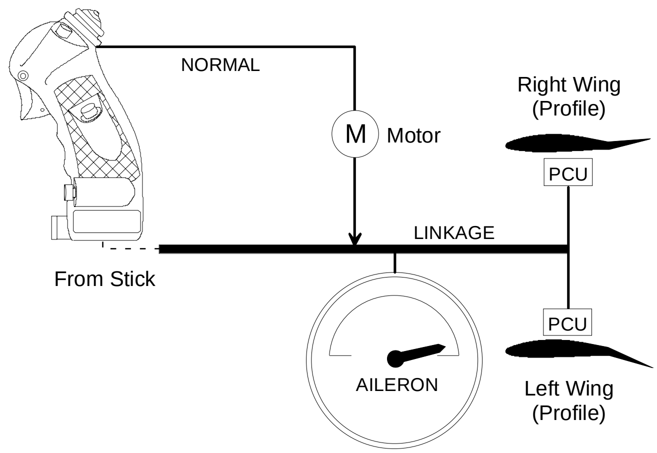


Figure 5: AILERON TRIM OPERATION

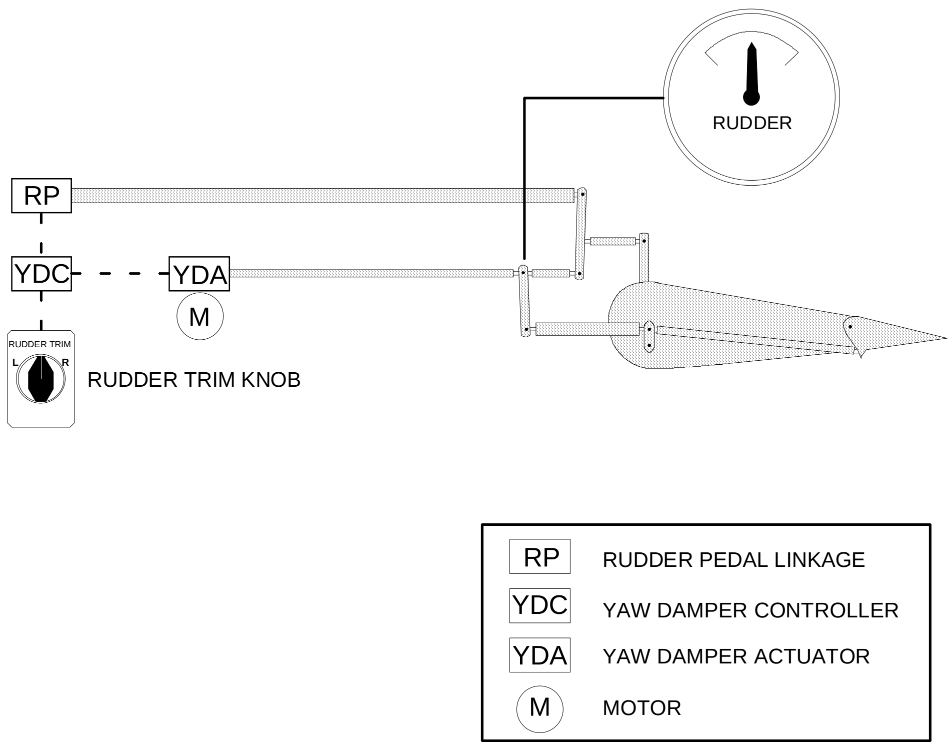


Figure 6: RUDDER TRIM OPERATION

AIRCRAFT RESPONSES TO FLIGHT CONTROL MALFUNCTIONS	
RESPONSE	**RELATED MALFUNCTION**
Aircraft ROLLS	Split flaps/slats, runaway aileron trim
Aircraft YAWS	Rudder hardover, runaway rudder trim
Aircraft PITCHES	Runaway stabilator trim

Figure 7: SUMMARY

LECTURE GUIDE

COURSE/STAGE: TS, ADV & IUT Engineering

LESSON TITLE: Egress System

LESSON IDENTIFIER: T-45C TS, ADV & IUT ENG-15

LEARNING ENVIRONMENT: Classroom

ALLOTTED LESSON TIME: 1.0 hr

TRAINING AIDS:

* NACES Ejection Seat Mockup
* Figures
  Fig 1: Canopy Control Levers
  Fig 2: Canopy Damper/Locking Strut
  Fig 3: Lost Motion Units
  Fig 4: T-45 Ladder & Aircraft Boarding System
  Fig 5: Main Beam Assembly
  Fig 6: Modes of Operation
  Fig 7: Minimum Safe Ejection Altitudes
  Fig 8: Ejection Seat Inspection
  Fig 9: Aft Cockpit
  Fig 10: Leg Restraint System

STUDY RESOURCES:

* T-45C NATOPS Flight Manual, A1-T45AC-NFM-000

LESSON PREPARATION:

Read:

* Part I, Chapter 2, relevant sections on canopy and ejection seat, T-45C NATOPS Flight Manual, A1-T45AC-NFM-000

(9-98) CHANGE 4

REINFORCEMENT: N/A

EXAMINATION:

The student is required to read canopy and ejection seat systems and related malfunction paragraphs in the NATOPS flight manual, receive classroom instruction, and complete assigned CAI lesson(s). The student shall demonstrate knowledge by completing, from memory with 80% accuracy, true/false and multiple choice block examinations. The objectives in this lesson will be tested in either Engineering 29X or Engineering 30X.

LESSON OBJECTIVES

1.3.5.1.4.5
Recall major components of the T-45 canopy

1.3.5.1.4.6
Recall functions of the canopy controls and indicators

1.3.5.1.4.7
Recall mild detonating cord (MDC) location and operating characteristics

1.3.5.4.1
Recall operating characteristics and components of the aircraft boarding system

1.3.5.1.4.2
Recall purpose and function of ejection seat components and controls

1.3.5.1.3
Recall operating characteristics of the ejection seat

1.3.5.1.3.1
Recall the ejection parameters

1.3.5.1.5
Recall procedures for checking/testing the ejection seat

MOTIVATION

Sg 0, fr 7, pg 2
Egress Graphic

In this lesson we will be talking about the canopy and ejection seat.

OVERVIEW

After this lesson, you will understand the canopy and ejection systems and how to operate them effectively. Further, you will know the location and function of the components, controls, and indicators of the T-45C canopy, aircraft boarding system and the Navy Aircrew Common Ejection Seat (NACES).

In this lesson we will discuss the:

* Canopy shell, frame, cockpit controls/indicators, and the mild detonating cord (MDC)
* Aircraft boarding system
* Navy aircrew common ejection seat (NACES)--major components, cockpit controls and operating characteristics
* Ejection parameters

PRESENTATION

I. Canopy **1.3.5.1.4.5**

Sg 1, fr 2
Lesson Organization

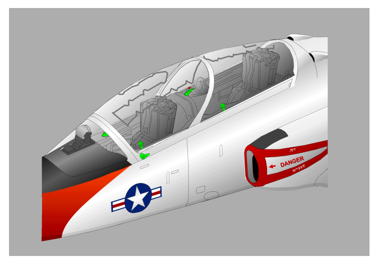
CANOPY AND EJECTION SEAT SYSTEMS
* **Canopy**
* T-45 Ladder/Boarding Systems
* NACES
* Ejection parameters
* Preflight

NOTE: Constructed of two joined and molded acrylic sheets, the canopy is hinged on the right and unlocks with the internal operating levers or external operating handle. The sideways-opening canopy is manually operated and can be secured in any desired position. The aft windscreen is attached to the canopy and provides separation between the fwd and aft cockpits and wind blast protection for the aft cockpit in case of a forward windscreen failure.

A. Shell: provides crew members a sealed transparent enclosure

B. Frame

Sg 1, fr 3
Canopy Components



1. Components

   a. Fwd and aft rear view mirrors

   b. Fwd and aft canopy control levers

   c. Canopy external handle lever

   d. Standby compass

   e. Canopy grab handle

   f. Canopy damper/locking strut

   g. Mild detonating cord (MDC) firing handle

2. Function: reinforces canopy, adds rigidity, forms attachment and locking points for canopy shell

Sg 1, fr 4
(2 overlays)
Fig 1: Canopy Control Levers

C. Cockpit controls/indicators and operational characteristics **1.3.5.1.4.6**

1. Fwd/aft canopy control levers

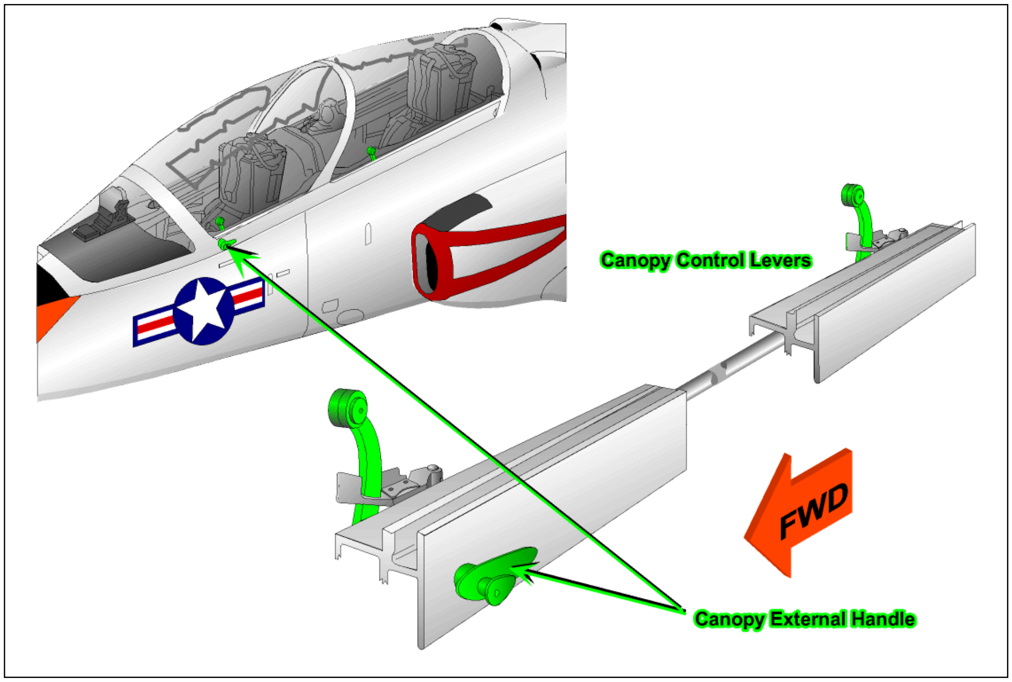


Figure 1: CANOPY CONTROL LEVERS

a. Location: fwd/aft left inside edge of canopy

b. Function: lock/unlock canopy locks and canopy lock strut

Overlay 1
Interconnecting Linkage

Overlay 2
Safety Catches

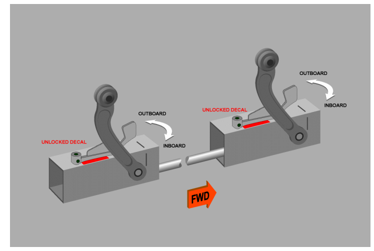
(1) Levers mechanically linked to each other and to external operating handle.

(2) Safety catches disengage locking mechanism to allow aft movement of canopy control lever. Full forward movement of canopy control lever allows safety catch engagement

NOTE: When either canopy control lever is held fully aft, the canopy swings partially open, a torque bar taking the weight of the canopy allows it to be manually positioned. When released the canopy is held in the selected position.

(3) UNLOCKED decal located under canopy control levers safety catches visible when safety catch is not fully engaged and canopy is not locked

Sg 1, fr 7
Canopy Controls



NOTE: Canopy should not be operated or remain open with side winds greater than 45 knots; when opening or closing, with winds greater than 20 knots, the nose of the aircraft should be pointed into the wind if possible.

2. Canopy external handle

Sg 1, fr 9
Canopy External Handle
Fig 1: *Canopy Control Levers*

a. Location: front port side

b. Function: locks/unlocks canopy from outside

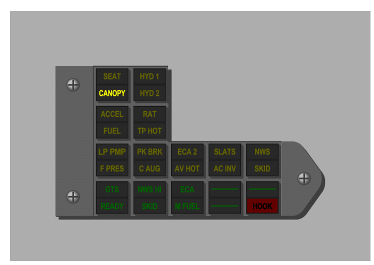
(1) Vertical position - unlocked

(2) Horizontal position - locked

NOTE: To operate the canopy external handle, press the pressure plate and then rotate the handle in a clockwise direction.

3. Canopy open (CANOPY) caution light

Sg 1, fr 10
Canopy Caution Light



a. Location: caution advisory panel, both cockpits

b. Function: indicates canopy not locked

NOTE: Illumination of the MASTER ALERT light and the presence of the caution tone will accompany the CANOPY caution light when the throttle is advanced past 95%. If the CANOPY caution light is illuminated, check the canopy control levers for full engagement (no UNLOCKED decal showing) and have ground personnel check the canopy external handle.

4. Canopy damper/locking strut

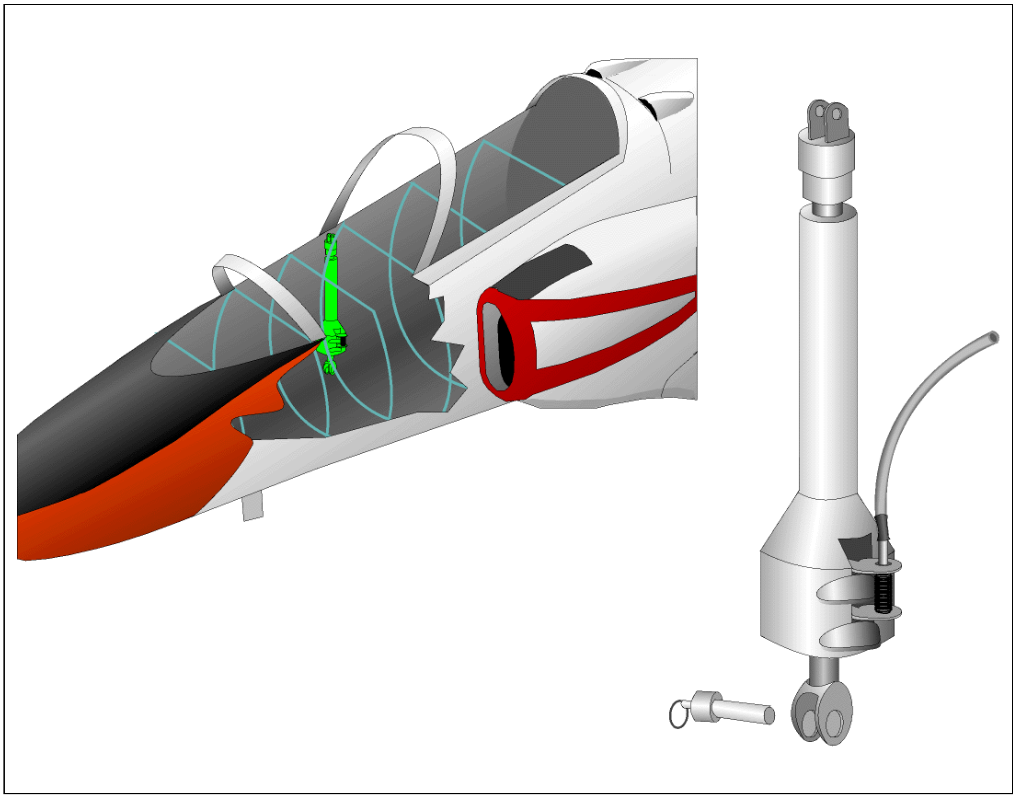


Figure 2: CANOPY DAMPER/LOCKING STRUT

Sg 1, fr 11
Fig 2: *Canopy Damper/Locking Strut*

a. Location: fwd cockpit, right side

b. Function: locks canopy in any position and prevents rapid opening and closing

Sg 1, fr 12
(3 overlays)
Forked Attachment
Fig 2: *Canopy Damper/Locking Strut*

Overlay 1
Piston Rod, Pin

Overlay 2
Lock Plates

Overlay 3
Teleflex Cable, Spring

c. Description

(1) Forked attachment to lever on canopy

(2) Piston rod connected by pin to cockpit floor attachment

(3) Lock plates with short and long lugs pivot against internal plates to lock rod in position

(4) Teleflex cable from canopy control levers control locking/unlocking action

5. Fwd/aft canopy mild detonating cord (MDC) firing handles

WARNING: Actuation of the MDC inadvertently or through the ejection process with the helmet visor up could result in severe eye injury.

Do not use the MDC firing handle or initiator cover as a handhold.

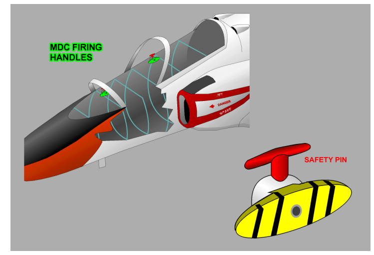
a. Location: both cockpits, inboard right-hand canopy edge

NOTE: The handles are color coded in yellow and black stripes and secured with a red safety pin during ground operations.

b. Function: initiates firing of MDC to shatter entire canopy

(1) Can be used during ground emergency egress and during flight in case of smoke in cockpit

Sg 1, fr 16
MDC Firing Handles



Sg 1, fr 17
Fig 3: *Lost Motion Units*

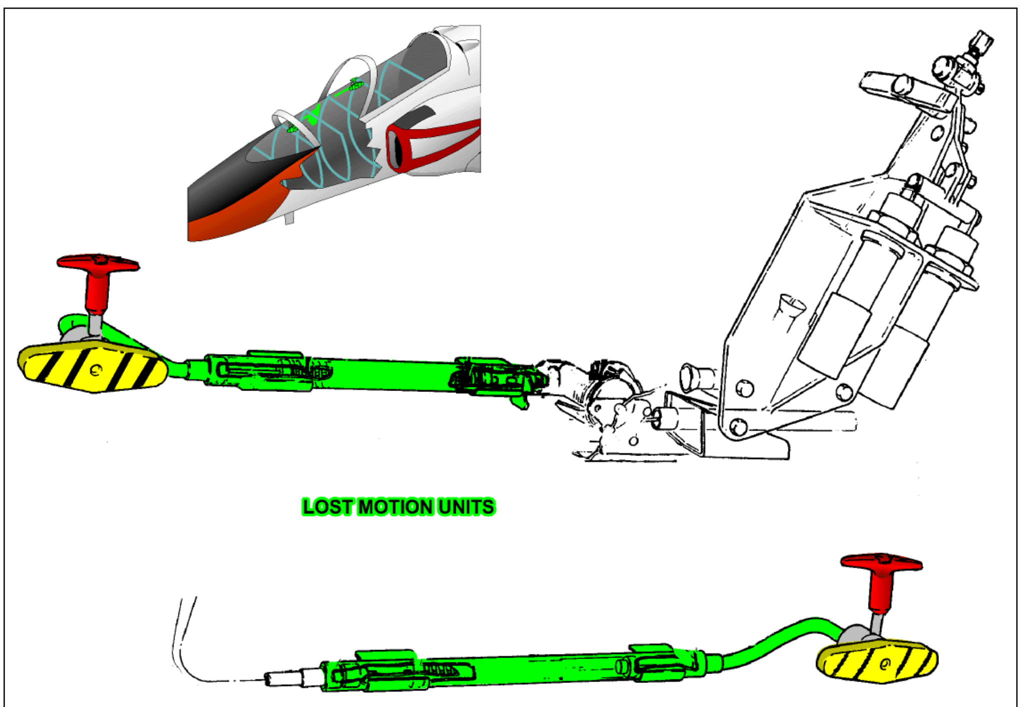


Figure 3: LOST MOTION UNITS

Sg 1, fr 18, ovl 1
Lever/Pulley Assembly
Fig 3: *Lost Motion Units*

Sg 1, fr 19, ovl 2
Explosive Initiator Lever
Fig 3: *Lost Motion Units*

(2) Each handle attached to lost-motion unit by cable

(a) Operating cable from MDC handle passes through lost motion unit

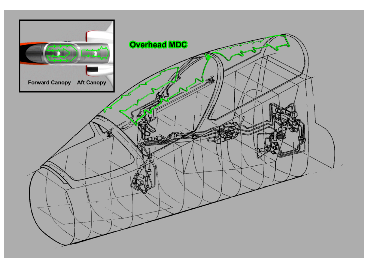
(b) Second cable attached to lever/pulley assembly

(c) Third cable to explosive initiator lever which fires initiators, thus shattering canopy

NOTE: This arrangement allows the pilot's hand to be withdrawn to a region of safety (approximately 4 inches). Only the last inch initiates firing.

D. Mild detonating cord (MDC) controls/indicators and operational characteristics **1.3.5.1.4.7**

Sg 1, fr 20
(3 overlays)
Overhead Mild Detonating Cord



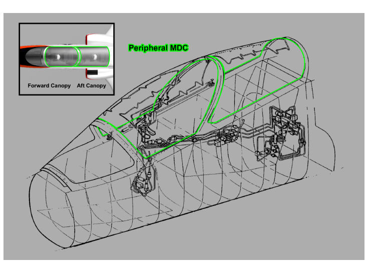
1. Overhead MDC

a. Location: attached to canopy around centerline

b. Function: shatters center portion of canopy during emergency egress

NOTE: Detonation is initiated by the crew pulling the fwd/aft MDC firing handle or it occurs as the automatic first step in the ejection sequence.

Sg 1, fr 21
Peripheral Mild Detonating Cord



2. Peripheral MDC

a. Location: attached to canopy around edge of canopy shell

b. Function: shatters canopy at edge of shell

NOTE: The peripheral MDC is partially covered by deflector plates to protect the aircrew from the blast resulting from MDC detonation.

3. Fuselage-mounted shielded MDC (SMDC)

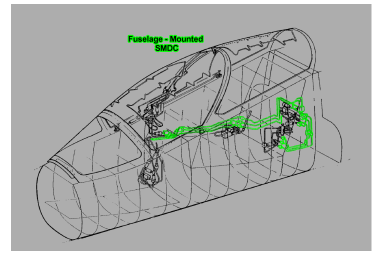
   a. Location: stainless steel conduit from aft wall of aft canopy to right frame member between canopy shells

   b. Function

      (1) provides interface between ejection seat and canopy

      (2) connects transfer initiator and canopy mounted SMDC

Sg 1, fr 22
Fuselage-Mounted Shielded Mild Detonating Cord

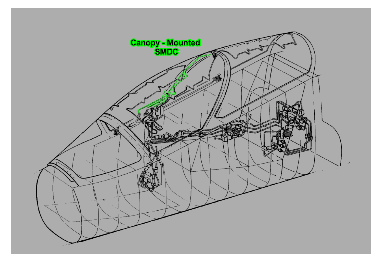


4. Canopy-mounted SMDC

   a. Location: from right frame member between canopy shells to connection of overhead and peripheral MDCs

   b. Function: connects ballistic gas-actuated SMDC explosive initiator, one-way transfer initiator, IFF switch, and overhead and peripheral MDCs

Sg 1, fr 23
Canopy-Mounted Shielded Mild Detonating Cord



E. Summary: The T-45C canopy consists of a shell and frame. It has three operating controls: the fwd and aft internal canopy controls and the canopy external handle. The fwd/aft MDC handles shatter the canopy without firing the seat

PROGRESS CHECK

Question 1 — 1.3.5.1.4.6
Which cockpit controls prevent or permit movement of the canopy control levers?

ANSWER: Canopy control lever safety catches

Sg 8, fr 2
Lesson Organization

CANOPY AND EJECTION SEAT SYSTEMS

* Canopy
* **T-45 Ladder/Boarding Systems**
* NACES
* Ejection parameters
* Preflight

Sg 8, fr 3
T-45 Ladder
Fig 4: *T-45 Ladder & Aircraft Boarding System*

Sg 8, fr 4
Aircraft Boarding System

II. T-45 aircraft boarding ladder & aircraft boarding system **1.3.5.4.1**

A. Boarding ladder

NOTE: Availability of the boarding ladder is limited to T-45 operational airfields.

B. Aircraft boarding system

1. Retractable footstep

2. Toe-in step

a. Location - above retractable footstep

3. Pull-out footsteps (two)

a. Location - above the toe-in step

b. Use - for entrance/exit from cockpits

4. Non-skid footstep - top of the left engine air intake

5. Two handholds

a. Location

(1) One on cross-ship structure between cockpits

(2) One on left side of glareshield

C. Operation

1. Retractable footstep

a. Lowered from outside cockpit only

(1) Move latch outboard

(2) Pull step down

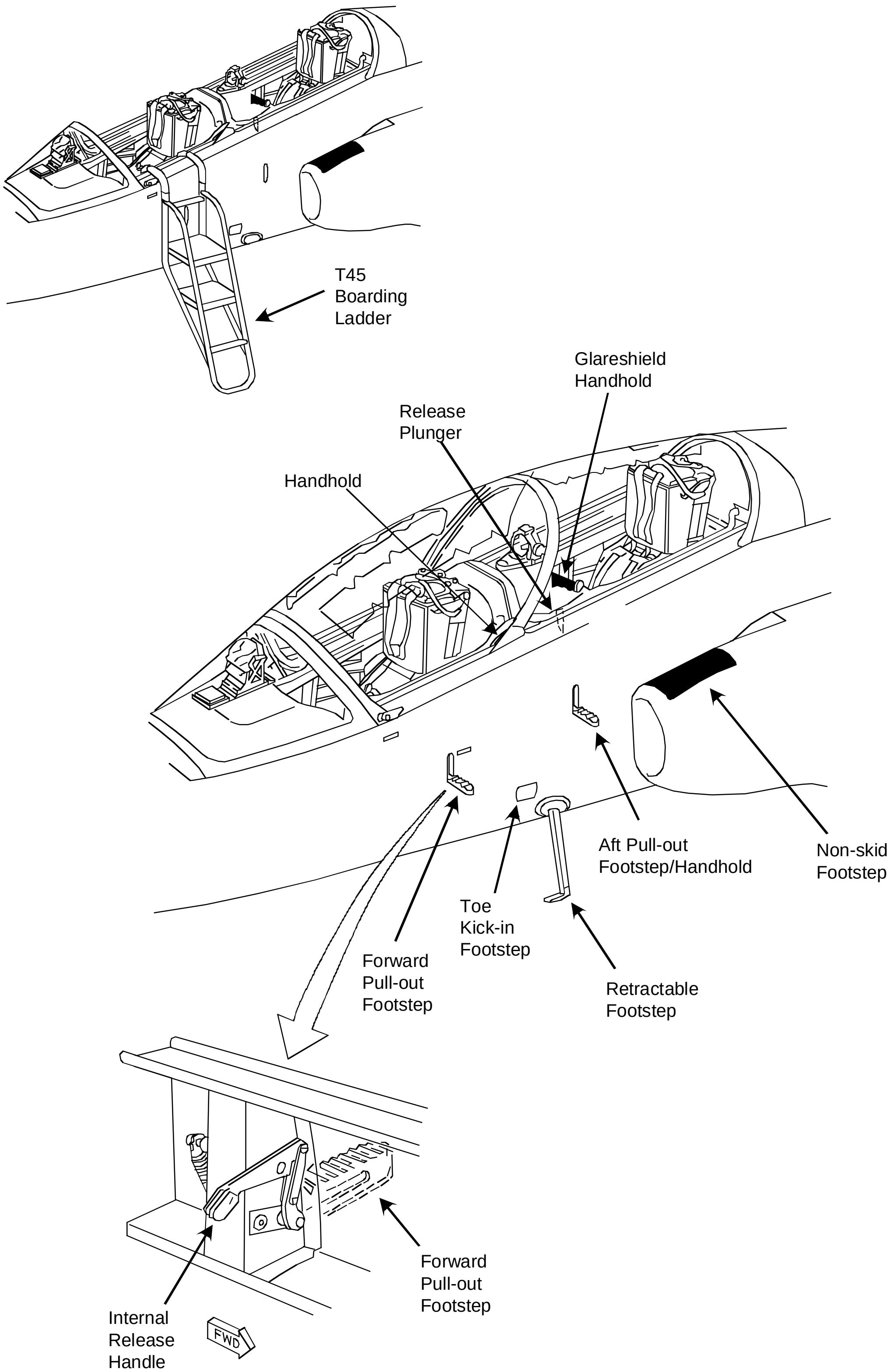


Figure 4: T-45 LADDER & AIRCRAFT BOARDING SYSTEM

NOTE: The retractable step will only lock down with the canopy open and will automatically retract when the canopy is closed. The footstep will not lock down when the canopy is closed. To retract footstep with the canopy open, the release plunger must be pressed manually.

2. Toe-in step - backplate with door spring-loaded to the closed position

3. Pull-out footsteps

   a. Forward footstep

      (1) Used for forward cockpit entrance/exit

      (2) Operated from inside or outside

      NOTE: An internal release handle mounted on the left fuselage structure allows operation of the forward footstep from inside the forward cockpit.

   b. Aft footstep

      (1) Used for aft cockpit entrance/exit

      (2) Used as handhold

      NOTE: The aft footstep can only be deployed from outside the cockpit.

      CAUTION: When entering or leaving the cockpit do not grasp the canopy transparencies or use the forward glareshield as a handhold.

      NOTE: If the aft cockpit aircrew elects to use the aft pull-out footsteps/handhold during egress, commence by stepping from the inlet duct position with the right foot instead of the left foot.

III. Navy aircrew common ejection seat (NACES) **1.3.5.1.4.2**

Sg 2, fr 2
Lesson Organization

CANOPY AND EJECTION SEAT SYSTEMS

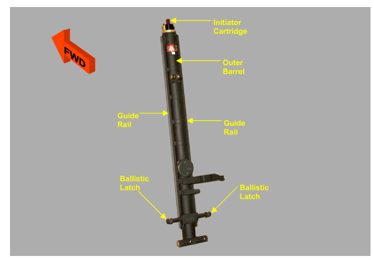
* Canopy
* T-45 Ladder/Boarding Systems
* **NACES**
* Ejection parameters
* Preflight

LESSON NOTES

Use the NACES ejection seat mock-up to demonstrate major points.

A. Major components

Sg 2, fr 3
Catapult Assembly



1. Catapult assembly

a. Location: back of ejection seat

b. Function: provides initial power to eject seat

c. Components

(1) Outer barrel

(2) Telescopic piston (inside outer barrel)

(3) Initiator cartridge

(4) Ballistic latch (2)

(5) Guide rails (2)

NOTE: Two guide rails attach the assembly to the main beams, and mounting lugs attach the assembly to the aircraft.

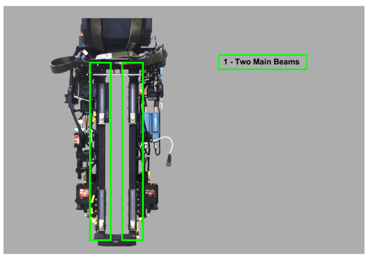
2. Main beam assembly

a. Location: back of seat between seat bucket and catapult assembly

b. Function: establishes tracks to control seat travel during catapult travel and ensures system rigidity

Fig 5: *Main Beam Assembly*

Sg 2, fr 4, pg 1
(6 overlays)
Ejection Seat Components



Overlay 1
Components 2, 3, 4

Overlay 2
Components 5, 6

Overlay 3
Component 7

Overlay 4
Components 8, 9

Overlay 5
Components 9, 10, 11

Overlay 6
Component 12

c. Components

(1) Two main beams and upper and lower crossbeams

(2) Shoulder Harness Retraction Unit

(3) Parachute deployment rocket

(4) Electronic sequencer

(5) Drogue Deployment Catapult

(6) Barostatic release unit

(7) Two start switch/rocket initiators

(8) Two thermal batteries

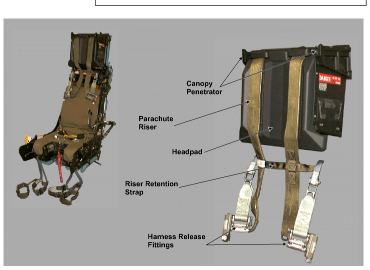
(9) Two pitot heads

(10) Drogue bridle release unit (2)

(11) Two ballistic manifolds

(12) Catapult manifold valve

Sg 2, fr 8
Parachute Assembly



3. Parachute assembly

a. Location: attached to upper forward face of main beams

b. Function: contains parachute assembly (6.2-meter conical) with risers extending down to standard harness release units attached to torso harness

NOTE: The parachute is packed in the metal head box and is not a visible item as in other ejection seats. A ribbon drogue used for parachute deployment is packed in a deployment bag within a rigid container.

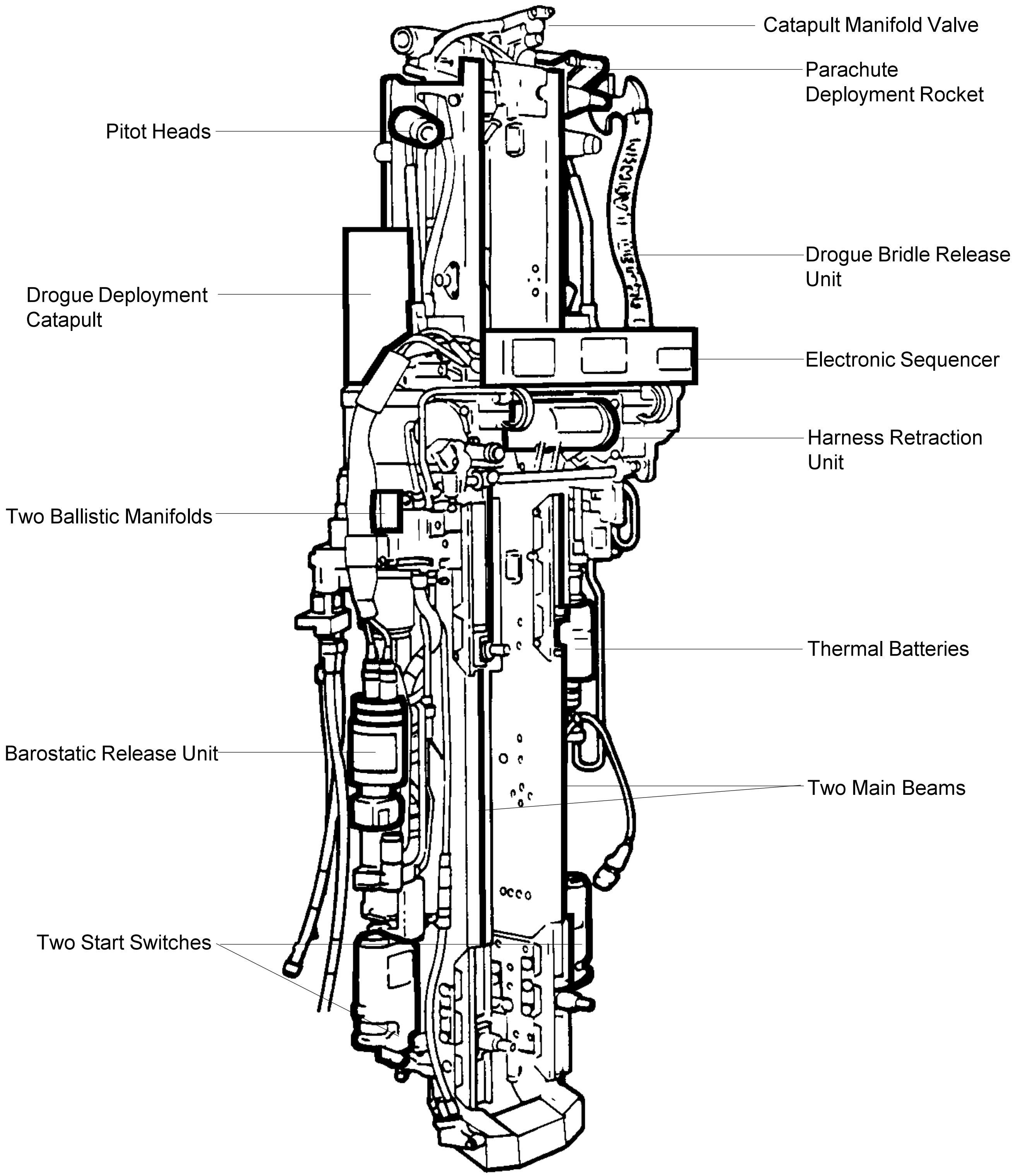
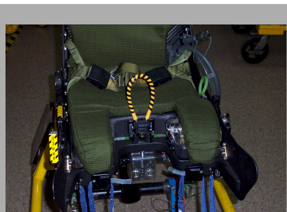
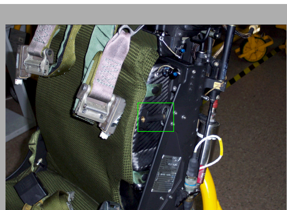


Figure 5: MAIN BEAM ASSEMBLY

Sg 2, fr 9
Ejection Seat Bucket


EJECTION SEAT BUCKET

Sg 2, fr 10
Backpad Adjustment Handle


BACKPAD ADJUSTMENT HANDLE

Sg 2, fr 11
Backpad Adjustment Handle, AFT Position

Sg 2, fr 12
Mid Position

Sg 2, fr 13
Forward Position

c. Components

(1) Parachute

(2) Canopy penetrators

(3) Parachute withdrawal lines

(4) Container cover

(5) Parachute risers

(6) Headpad

(7) Riser retention strap

(8) Harness release fittings and SEAWARS

4. Ejection seat bucket

a. Location: lower portion that holds seat cushion and back

b. Function: forms seat and provides attachment points for controls and life-support systems

c. Components

(1) Backpad adjustment handle

(a) Location: Upper aft portion of seat bucket

(b) Function: to accommodate aircrew with less forward reach

(c) Control: three (3) position selector

(d) Operation: allows 1 5/8" horizontal forward displacement in 3 increments

(2) Seat height adjustment switch

(a) Location: fwd left side of seat bucket

(b) Function: controls electro-mechanical actuator to adjust seat height

i) When forward (press and hold), lowers seat

ii) When off, maintains seat at selected height

iii) When aft (press and hold), raises seat

iv) Limited to 1 minute operation in any 8 minute period

v) With Aircrew Systems Change 646 (p^3I modifications), provides longer seat height actuator travel and shortened seat bucket, which together, provides 1 inch extra seat bucket up travel

CAUTION: Activation of the seat bucket with lap belt and/or shoulder harness outside of the seat bucket may damage ejection seat and/or KOCH fittings.

Sg 2, fr 14
Seat Height Adjustment Switch

SAFE/ARMED HANDLE - SAFE POSITION

(3) Shoulder harness control lever

(a) Location: center left side of seat bucket

(b) Function: controls shoulder harness reels allowing or preventing forward movement by pilot

(c) Automatically locks at 0.7g negative/ deceleration

Sg 2, fr 15
Shoulder Harness Control Lever

SAFE/ARMED HANDLE - ARMED POSITION

i) FORWARD - lock shoulder harness inertia reel

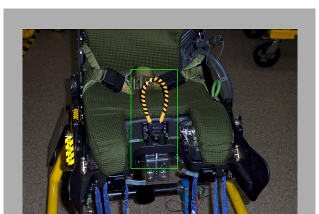
ii) AFT - unlocks shoulder harness inertia reel

iii) CYCLINE - releases shoulder harness inertia reel after it has automatically locked

LESSON NOTES

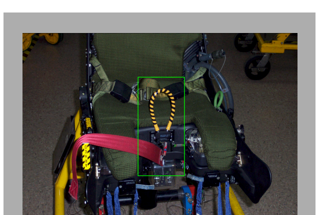
Provide examples of the controls that may be out of reach until the shoulder harness is loosened with the shoulder harness control lever, i.e., rudder pedal adjust knob, leg restraint plugs.

Sg 2, fr 16
Ejection Control Handle Without Safety Pin



EJECTION CONTROL HANDLE WITHOUT SAFETY PIN

Sg 2, fr 17
Ejection Control Handle With Safety Pin



EJECTION CONTROL HANDLE WITH SAFETY PIN

(4) Ejection handle

(a) Location: forward center of seat bucket

(b) Function: initiates ejection sequence (working in conjunction with SAFE/ ARMED handle)

i) Dual loop, color-coded (yellow and black) and secured during ground operations by safety pin

ii) Requires pull force of 25 to 40 pounds to remove the ejection handle from its housing. A continued pull force of 30 to 60 pounds is required to initiate ejection

iii) 3 inch pull, only last inch actuates

iv) With Aircrew Systems Change 646 (p^3I modifications) the seat firing handle is a single rubber loop, color-coded (yellow and black) and secured by a safety pin

(5) SAFE/ARMED handle

Sg 2, fr 18
SAFE/ARMED Handle
SAFE Position

SAFE/ARMED HANDLE - SAFE POSITION

(a) Location: right-hand side of seat bucket

(b) Function: places ejection system in safe or armed condition

WARNING: With one seat armed and one set safe, the armed seat can initiate ejection of both seats.

Sg 2, fr 19
SAFE/ARMED Handle
ARMED Position

SAFE/ARMED HANDLE - ARMED POSITION

i) Color coded with yellow and black stripes

ii) Equipped with a catch to lock the handle in the SAFE or ARMED position

CAUTION: Ensure the SAFE/ ARMED handle is in the SAFE or ARMED position. It is possible for the handle to be positioned between the SAFE and ARMED positions.

NOTE: The SEAT UNARMED caution light will illuminate, accompanied by MSTR ALERT light and caution tone with the SAFE/ARMED handle in the SAFE position and the throttle advanced past 70%.

(6) Emergency restraint release handle (manual override handle)

Sg 2, fr 20
Emergency Restraint
Release Handle

EMERGENCY RESTRAINT RELEASE HANDLE

(a) Location: right side of seat bucket

(b) Function:

i) On ground: initiates quick release of lower torso, and leg restraint system

WARNING: Never actuate the emergency restraint release before ejection. Actuation of the handle releases the pilot from the seat and moves the SAFE/ARMED handle to the SAFE position, making ejection initiation by the seat occupant impossible. Further, if ejection is then initiated by the other cockpit, both seats will be ejected with probable fatal results.

ii) In air: initiates manual separation of man/seat and fires parachute drogue deployment rocket

NOTE: The handle is used during ground emergency egress or during ejection if normal seat separation fails to occur below 14,000 ft MSL.

NOTE: During emergency egress, the upper torso quick release fittings must be manually disengaged.

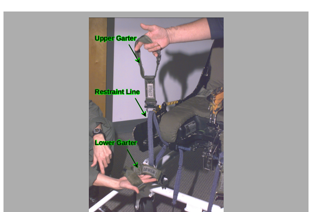
(7) Leg restraint system

(a) Location: fwd of seat bucket

(b) Function: secures legs to front of seat bucket during ejection to prevent them from flailing in airstream

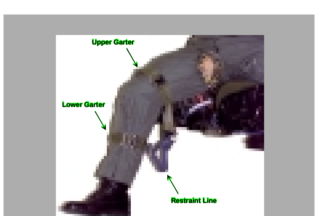
NOTE: The leg restraint system is released during emergency pilot/seat separation by pulling the emergency restraint release handle.

Sg 2, fr 21
Leg Restraint System



LEG RESTRAINT SYSTEM

Sg 2, fr 22
Leg Restraint Garters Properly Positioned



LEG RESTRAINT GARTERS - PROPERLY POSITIONED

(c) Components

i) Leg restraint lines

ii) Leg restraint line locks (tapered plug)

iii) Adjustable leg garters

iv) Adjustable snubbing unit

(8) Rocket motor

(a) Location: mounted on bottom of seat pan assembly

(b) Function: provides upward and lateral thrust, ensuring that seats travel in opposite lateral directions, fwd going left and aft going right

5. Survival kit (seat pan)

a. Location: bottom portion of seat bucket assembly

b. Function: provides additional life-support items

NOTE: The survival kit and seat pan are an integrated unit in the NACES.

c. The survival kit may be deployed after seat/man separation by pulling either the left or right raft release handles on the AFT portion of the survival kit

d. Components

(1) Emergency oxygen supply

(a) Automatically activated upon seat ejection by lanyard attached to aircraft floor (deck)

Sg 2, fr 23
Snubber Line Locks (Tapered Plug)

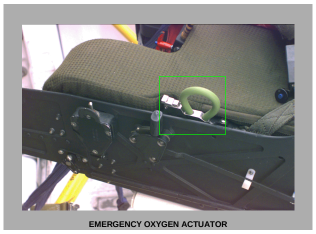
Sg 2, fr 24
Leg Garters

Sg 2, fr 25
Snubbing Unit

Sg 2, fr 26
Seat Pan Raft Release Handles

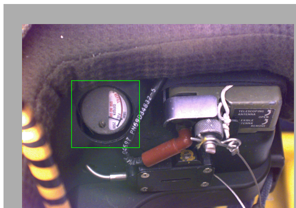
SEAT PAN - RAFT RELEASE HANDLES

Sg 2, fr 27
Emergency Oxygen Actuator



EMERGENCY OXYGEN ACTUATOR

Sg 2, fr 28
Emergency Oxygen Gauge



EMERGENCY OXYGEN GAUGE

(b) Manually activated/deactivated by green emergency oxygen handle located on the left side of the seat cushion (can be turned ON or OFF by pilot)

(c) Gauge located on inside left of seat pan

(d) Full cylinder of 1,800 to 2,500 psi holds 4- to 20-minute supply

(2) Life raft

(a) Released for inflation when crew member deploys lower part of kit

(b) Attached to lanyard for retrieval

(3) Survival aids

(a) Bailing sponge

(b) Plastic tube

(c) Canned water

(d) Sea dye markers

(e) Nylon cord

(f) Flares

(g) Code card

(h) Can opener

(i) Space blanket

(4) Personal locator beacon (emergency locator transmitter)

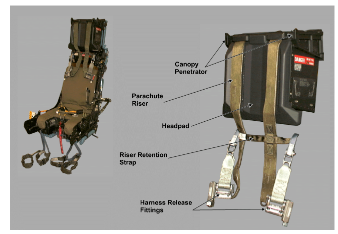
(a) Location: left side of survival kit

(b) Function: transmits emergency signal on 243.0 MHz and 121.5 MHz

NOTE: The locator beacon is activated during ejection by a lanyard attached to the aircraft floor (deck).

6. Main parachute

Sg 2, fr 29
Parachute Assembly



a. Location: stored in an environmentally sealed metal container on top of ejection seat

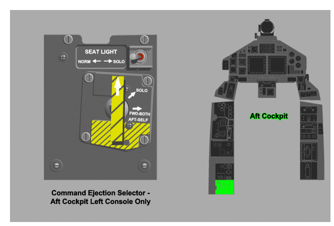
b. Function: establishes acceptable rate of descent for crew member

NOTE: A deployment rocket extracts the parachute from its container.

NOTE: No ballistic spreader gun; parachute is aerodynamically designed for rapid opening.

B. Cockpit controls: command ejection panel

Sg 2, fr 30
(2 overlays)
Command Ejection Selector and Seat Light Switch



1. Location: left console, aft cockpit only

2. Function: seat light switch and command ejection selector handle allow crew to manage ejection sequence

3. Components

a. SEAT LIGHT switch

(1) Positions: switch is spring-loaded to NORMAL and must be pinned to SOLO

(2) Function: controls SEAT UNARMED caution light on caution advisory panel

(a) Switch in NORMAL: if either seat is unarmed and throttle position exceeds 70% N_2 RPM, MSTR ALERT flashes, SEAT UNARMED on WCP illuminates, and caution tone sounds

(b) Switch pinned to SOLO: aft seat UNARMED indicators are disabled

b. Command ejection selector positions

(1) BOTH: initiation of either fwd or aft seat fires aft seat, then fwd seat with a 0.4-second delay between firings

Overlay 1
FWD-BOTH/ AFT-SELF

(2) FWD-BOTH/AFT-SELF

(a) Initiation by fwd seat fires aft seat followed 0.4 second later by fwd seat

(b) Initiation by aft seat fires aft seat only

NOTE: If ejection is initiated by the FWD seat, the FWD seat firing circuit is routed through a 0.5 second delay cartridge. This serves as a backup to the 0.4 second delay initiator.

Overlay 2
SOLO

(3) SOLO

(a) Selected with red metal selector collar and red safety pin on seat light switch installed

(b) Actuation of fwd ejection handle ejects fwd seat only (No 0.4 second delay)

(c) Actuation of aft ejection handle ejects aft seat only

WARNING: Automatic command ejection sequencing is impossible with the selector in the SOLO position. If ejection is simultaneously initiated in this mode, the seats may collide.

C. Operating characteristics **1.3.5.1.3**

1. Secures crew member

2. Supplies life support and communication connection points

3. Ejection

   a. Ejection seat has 0-0 (airspeed-altitude) ejection capability, electronic sequencer adjusts to altitude and airspeed requirements

      NOTE: Assumes no rate of descent and wings-level attitude, nose on horizon (zero rate of descent, zero rate of roll, and zero rate of pitch).

   b. Assumes pilot falls within the weight limits established for this ejection seat. (Prior to Aircrew Systems Change 646 installation)

      WARNING: During ejection seat development and testing, the SJU-17V 5/A and SJU 17(V) 6/A were qualified for use by aviators with nude weights from 136 lbs. to 212 lbs. Operation of the seat by personnel not within these parameters subjects the occupant to increased risk of injury.

      (1) Less than 136 lbs nude:

          At greater risk from higher catapult accelerations, seat instability, and opening shock

      (2) Greater than 213 lbs nude:

          At greater risk from insufficient altitude for parachute full inflation at low altitudes and may not attain sufficient altitude to clear the aircraft's tail structure

   c. With Aircrew Systems Change 646 (p^3I installed), a new catapult cartridge, with a choked exit and new rocket fuel propellant, provides improved performance under imposed "g" conditions which accommodates aircrew personnel who are within an expanded (100-245 lbs) nude weight range

d. Canopy fragmentation system is synchronized to ejection seat initiation

e. Ejection seat sequence same whether canopy is in place or shattered via MDC prior to ejection

NOTE: Your canopy will not shatter during ejection sequence, until your seat's ejection sequence is initiated.

f. Upon separation of ejection seat from catapult, electronic sequencer controls all events (e.g., drogue chute deployment, man/seat separation, main chute deployment)

NOTE: A barostatic release mechanism is used as a backup in the event of an electronic sequencer failure at 18,000 ft. Activates between 14,000 and 16,000 ft.

g. Parachute deployment totally dependent upon ejection seat initiation. If seat fails to fire, manual bailout is impossible

WARNING: Ejection with canopy in any position other than fully closed and locked is not recommended. Serious bodily injury and seat malfunction may occur.

NOTE: Airspeed for minimum parachute opening shock is 200 kts or less. Due to the unique features of NACES, peak parachute opening shock load occurs around 280 kts. Parachute ejection above 200 kts would receive the least opening shock in the 320-350 kts range due to the benefits of the drogue phase to stabilize and decelerate the seat. Above 600 kts, ejection becomes extremely hazardous. As in all tactical jets, given a choice, slow your aircraft as slow as practical in straight and level flight, trimmed, before ejecting.

h. Ejection event sequence from initiation through end of catapult stroke

(1) In cockpit: pull ejection handle

(2) Gas travels from right seat firing cartridge to lower quick-disconnect and to gas-to-SMDC initiator

(3) SMDC ignites, passing signal to sequencer, selector, and fwd or aft seat

NOTE: If BOTH selected on selector, signal travels to aft canopy first and initiates IFF en route.

(4) Aft canopy shatters and SMDC-to-gas initiator fires aft ejection seat

NOTE: If the MDC fails, the canopy penetrator, located on top of the seat, will shatter the canopy.

(a) After 0.4-second delay, forward cockpit canopy shatters and SMDC-to-gas initiator fires forward ejection seat

(5) Thermal batteries activate

(6) Harness retraction unit retracts shoulder straps

(7) Catapult initiates

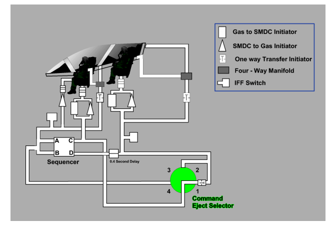
(8) Rocket initiator static lines begin to withdraw

(9) Ballistic and electrical quick-disconnects separate

(10) Quick-disconnect fittings for pilot services (oxygen, COMM, G suit) separate

(11) Emergency oxygen supply and radio beacon activate

Sg 2, fr 31
(4 overlays)
Ejection Initiation Event Sequence



Overlay 1
Gas-to-SMDC Initiation

Overlay 2
SMDC Ignition
SMDC to Aft Cockpit

Overlay 3
Aft Canopy Shatters, Aft Seat Fires

Overlay 4
Forward Canopy Shatters, Forward Seat Fires

Sg 2, fr 32
Fig 6: *Modes of Operation*

(12) Leg restraint system activated

(13) End of catapult travel

NOTE: Near the end of the catapult stroke, the rocket initiator static lines become taut and withdraw the mechanism sears. Gas pressure from the rocket initiator cartridge is directed to the following items.

(a) Start switch plungers (commence sequencer timing)

(b) Barostatic release unit

(c) Pitot mechanism to deploy pitot heads

(d) Underseat rocket motor

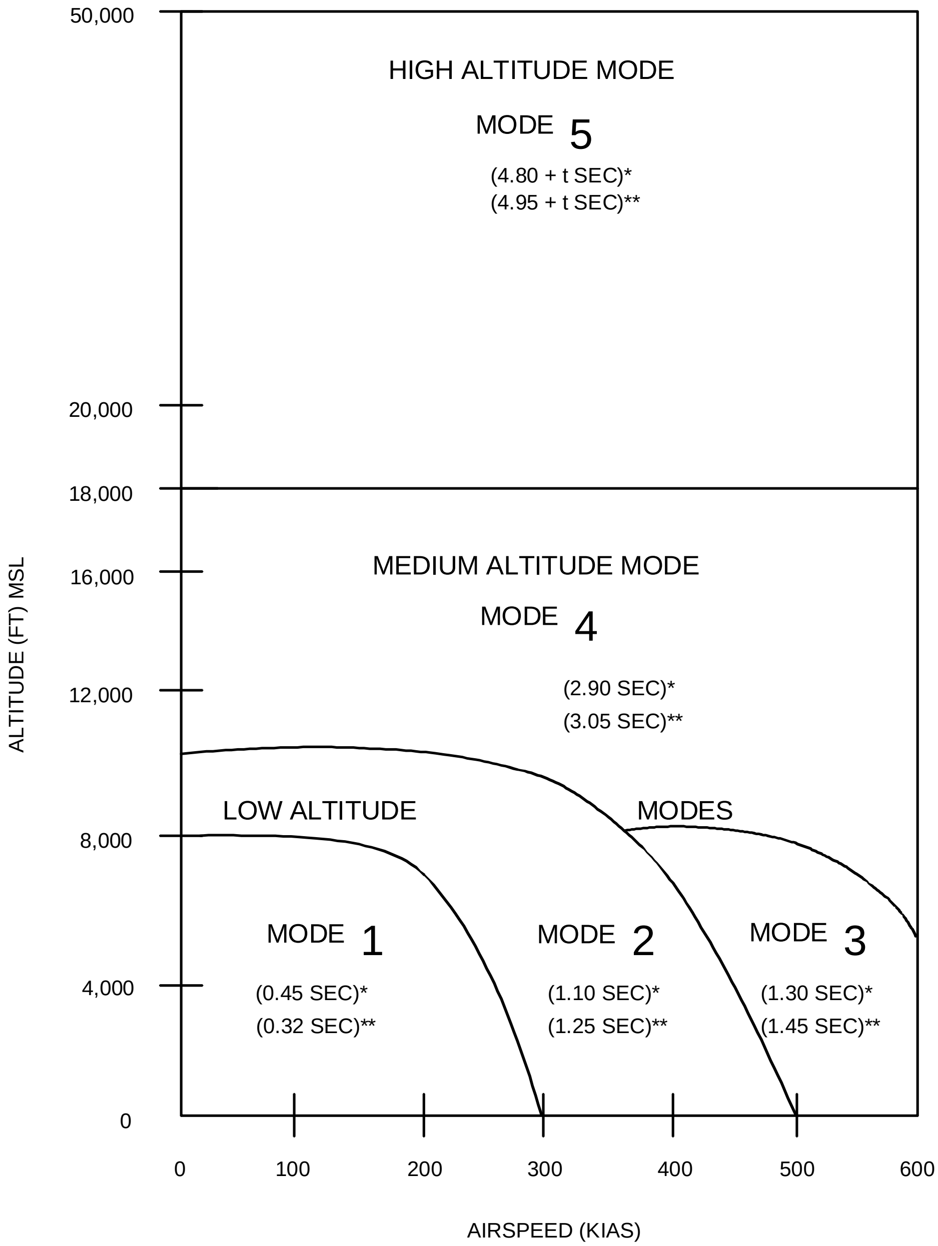
NOTE: The underseat motor is fired to sustain catapult thrust and ensure that the seat clears the aircraft.

(14) Ejection mode sequence

(a) Mode determined by electronic sequencer based on altitude and airspeed data from pitot heads at time of ejection

NOTE: The ejection mode sequence follows one of five modes. Modes 1, 2, and 3 are defined to include ejection where the aircraft is operating at low altitudes and airspeeds. Mode 4 occurs at intermediate altitudes and any airspeed. Mode 5 occurs at high altitudes (greater than 18,000 ft) and at any airspeed.

(b) Drogue chute deploys onto bridles, regardless of mode selected, to stabilize and decelerate seat



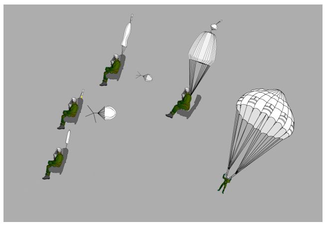
* Parachute deployment time after initial seat movement.

** Drogue bridle release time after initial seat movement.

t = Time interval between 4.80 seconds
and fall to 18,000 feet.

Figure 6: MODES OF OPERATION

Sg 2, fr 33
Mode 1 Ejection Sequence



(c) Mode 1

i) Drogue chute bridles release 0.32 seconds after seat's first motion

ii) Parachute deployment rocket fires to deploy parachute

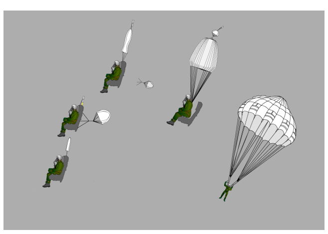
iii) Harness release system operates

iv) Pilot released from seat but held momentarily by sticker straps

NOTE: Sticker straps are pulled from their clips when the parachute fully deploys. This prevents collision between the pilot and the seat after separation.

v) Parachute lifts pilot with survival kit from seat

Sg 2, fr 33, pg 2
Modes 2, 3, and 4 Ejection Sequence



(d) Modes 2, 3, and 4

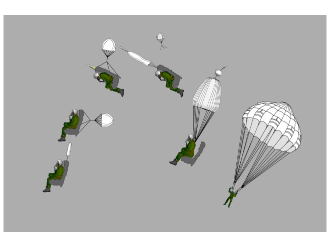
i) Drogue chute decelerates seat

ii) After time delay determined by electronic sequencer, parachute deployment rocket fires to deploy parachute before the drogue chute bridles are released

iii) Harness release system operates

iv) Pilot released from seat

Sg 2, fr 34
Mode 5 Ejection Sequence



(e) Mode 5

i) Seat descends with drogue chute bridles connected to 18,000 feet where bridles release

NOTE: This prevents prolonged exposure to low temperatures and thin air.

ii) Parachute deployment rocket fires to deploy parachute

a) Rocket falls free of parachute when expended - all modes

iii) Harness release system operates

iv) Pilot released from seat

D. Summary: the NACES ejection seat consists of a catapult assembly, main beams, a parachute assembly, and seat bucket assembly. Attached to the seat bucket are the seat height adjustment switch, shoulder harness control lever, ejection handle, SAFE/ARMED handle, emergency restraint release handle, leg restraint system, and rocket motor. The survival kit contains the emergency oxygen supply, life raft, survival aids, and emergency locator beacon and is stored in the seat bucket. The ejection sequence selector panel has a SEAT LIGHT switch spring loaded to NORMAL and must be safety pinned to the SOLO position. The command ejection selector handle has three positions, FWD-BOTH/AFT-SELF, BOTH, and SOLO. There are five ejection modes automatically selected by the seat based on altitude and airspeed at the time of ejection.

PROGRESS CHECK

Question 2 — 1.3.5.1.3
Which positions must the canopy be in to initiate a safe ejection?

ANSWER: Closed and locked

Question 3 — 1.3.5.1.4.2
What is the purpose of the shoulder harness control lever?

ANSWER: It allows locking or unlocking of the shoulder harness reels, allowing or inhibiting forward movement by the pilot

PROGRESS CHECK

Question 4 — 1.3.5.1.3
Why is it necessary to pin the seat light switch to the SOLO position?

ANSWER: To bypass logic circuit that illuminates seat caution light above 70% N_2 when aft seat not occupied

Question 5 — 1.3.5.1.3
What is the function of the drogue parachute during high altitude ejection?

ANSWER: To stabilize the seat and prevent tumbling

Sg 3, fr 2
Lesson Organization

CANOPY AND EJECTION SEAT SYSTEMS
* Canopy
* T-45 Ladder/Boarding Systems
* NACES
* **Ejection parameters**
* Preflight

Sg 3, fr 3
Fig 7: *Minimum Safe Ejection Altitudes*

IV. NATOPS ejection parameters **1.3.5.1.3.1**

A. Minimum safe ejection altitudes—refer to charts in NATOPS section V, figure 17-2 (sheets 1 through 3)

NOTE: There are two additional ejection charts not replicated in this manual refer to your NATOPS as indicated above.

Sg 7, fr 2
Lesson Organization

CANOPY AND EJECTION SEAT SYSTEMS
* Canopy
* T-45 Ladder/Boarding Systems
* NACES
* Ejection parameters
* **Preflight**

V. Preflight checklist/servicing requirements **1.3.5.1.5**

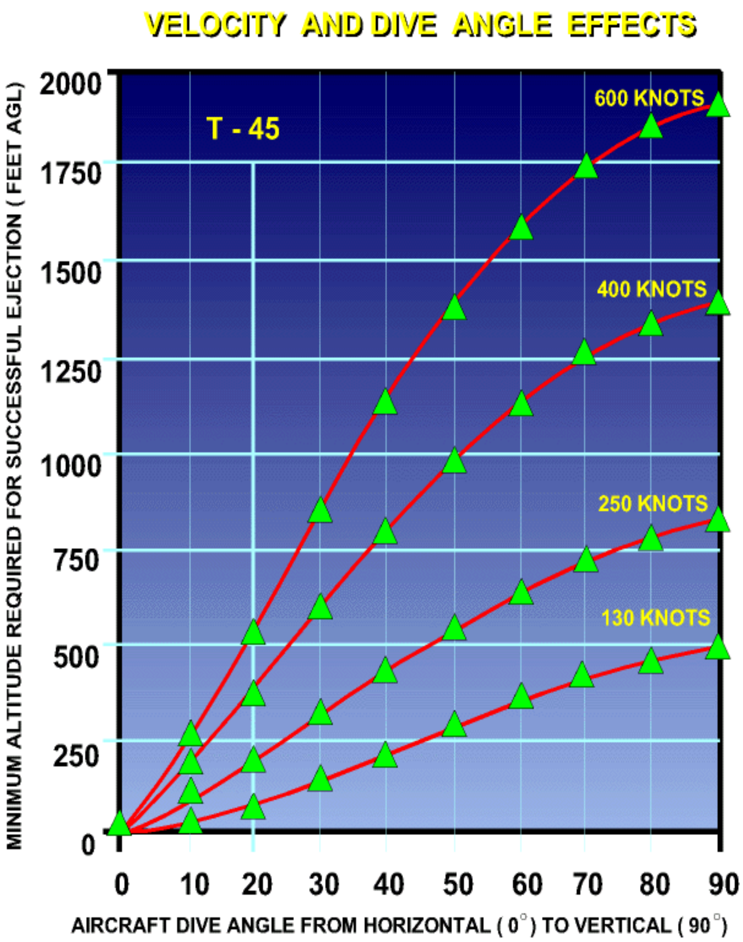
NOTE: The following italicized steps on preflight checks/ services are excerpted from NATOPS procedures.

A. Entering Cockpit

1. Cockpit area

a. Windscreen/canopy - CHECK SECURED, NO DEEP SCRATCHES, NO DELAMINATION, SEALS GOOD

b. MDC firing handle safety pin - REMOVED AND STOWED



NOTES:

- Minimum ejection heights are based on initiation of the escape system, and the time required for a complete dual sequenced ejection is included.
- Pilot reaction time is not included
- Ejection altitude is below 5000 ft. MSL

Figure 7: MINIMUM SAFE EJECTION ALTITUDES

Sg 7, fr 3
SAFE/ARMED Handle SAFE Position
Fig 8: Ejection Seat Inspection
Sg 7, fr 4
Emergency Restraint Release Handle
Sg 7, fr 5
Ejection Control Handle Without Safety Pin
Sg 7, fr 6
Emergency Oxygen Actuator - OFF
Sg 7, fr 7
Emergency Oxygen Gauge
Sg 7, fr 8
Leg Restraint Cables
Sg 7, fr 9
Emergency Locator Transmitter and Oxygen Lanyards

Sg 7, fr 10
Top of Ejection Seat
Sg 7, fr 11
Catapult Manifold Valve, Hoses, and Retaining Pin
Sg 7, fr 12
Catapult Manifold Valve Lock-in Plunger Correctly Installed
Sg 7, fr 13
Catapult Manifold Valve Lock-in Plunger Incorrectly Installed
Sg 7, fr 14
Parachute Withdrawal Lines
Sg 7, fr 15
Jammed Upper Koch Fitting
Sg 7, fr 16
Top Latch Mechanism Spigot Indicator Flush

c. *Ejection seat safety pin - REMOVED AND STOWED*

d. *Ejection seat - INSPECT*

(1) *Ejection seat SAFE/ARMED handle - SAFE*

(2) *Emergency restraint release - FULLY DOWN AND LOCKED*

(3) *Ejection control handle safety pin - REMOVED AND STOWED*

(4) *Emergency oxygen actuator - OFF*

(5) *Emergency oxygen gauge - 1,800 to 2,500 PSI*

(6) *Leg restraint cables - CONDITION/ PROPERLY ROUTED*

(7) *Emergency locator transmitter and oxygen lanyards - CONNECTED*

(8) *Catapult manifold valve - SECURED, HOSE CONNECTED AND RETAINING PIN INSTALLED*

(9) *Parachute withdrawal line - CORRECTLY SECURED TO PARACHUTE DEPLOYMENT ROCKET STIRRUP*

CAUTION: To prevent SEAWARS/ trombone damage, do not adjust seat prior to strapping in.

(10) *Top latch mechanism - SPIGOT INDICATOR IS FLUSH WITH END OF TOP LATCH PLUNGER*

WARNING: If top latch mechanism does not meet outlined requirements, seat could rise up catapult guide rail during aircraft maneuvers.

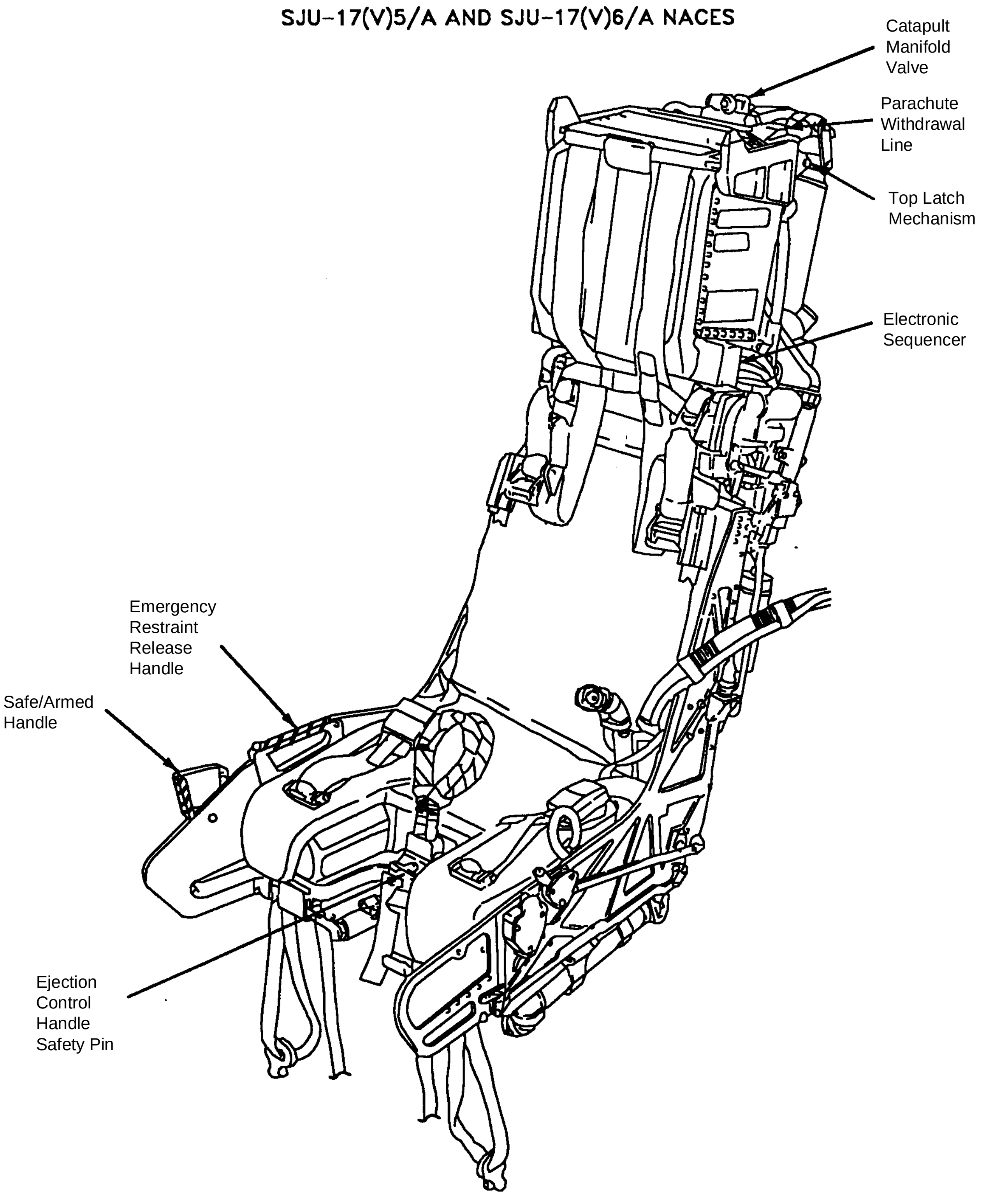


Figure 8: EJECTION SEAT INSPECTION

Sg 7, fr 17
Electronic Sequencer Indicator
Fig 9: *Aft Cockpit (Solo Flight)*

Sg 7, fr 18
Backpad Adjustment Handle

(11) Electronic sequencer - CHECK INDICATOR FOR BLACK

(12) Backpad adjustment handle - SET (AFTER AFC-250)

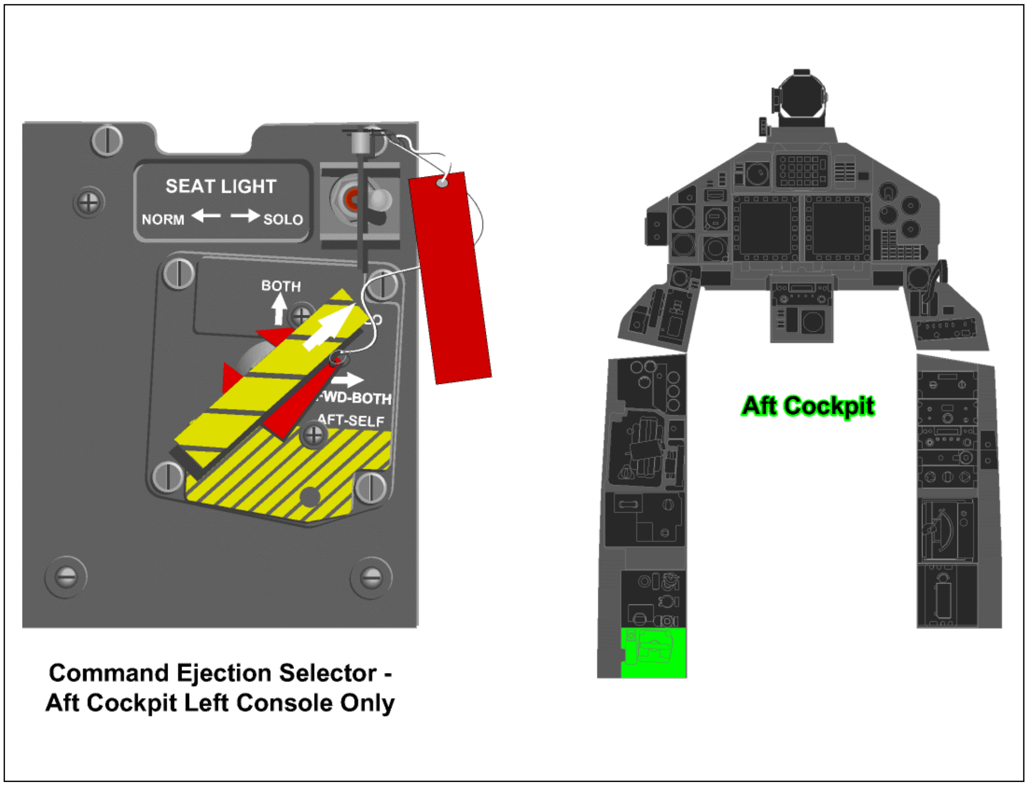


Figure 9: AFT COCKPIT

Sg 7, fr 19
(1 overlay)
AFT Cockpit (Solo Flight)

Overlay 1
SEAT LIGHT Switch

2. *Aft Cockpit (solo flight)*

   a. *Command ejection selector - SECURED IN SOLO POSITION, COLLAR INSTALLED*

   b. *SEAT LIGHT switch - PINNED IN SOLO*

   c. *Ejection seat SAFE/ARMED handle - SET TO SAFE*

   d. *Ensure MDC safety pin streamer secured by velcro to canopy rail*

   e. *All loose items including harness - SECURE* *f. Ensure MDC and ejection seat safety pin streamer is routed beneath right side lap belt*

WARNING: Failure to route integrated streamer beneath right side lap belt when ejection seat is set for solo flight may allow streamer assembly to foul the aft cockpit control stick.

g. All loose items including harness - SECURE

h. Ejection seat - LOWER TO FULL DOWN POSITION

CAUTION: To prevent SEAWARS/trombone damage, do not adjust seat prior to securing the harness.

i. Ensure MDC safety pin streamer secured by velcro to canopy rail

j. All loose items including harness - SECURE

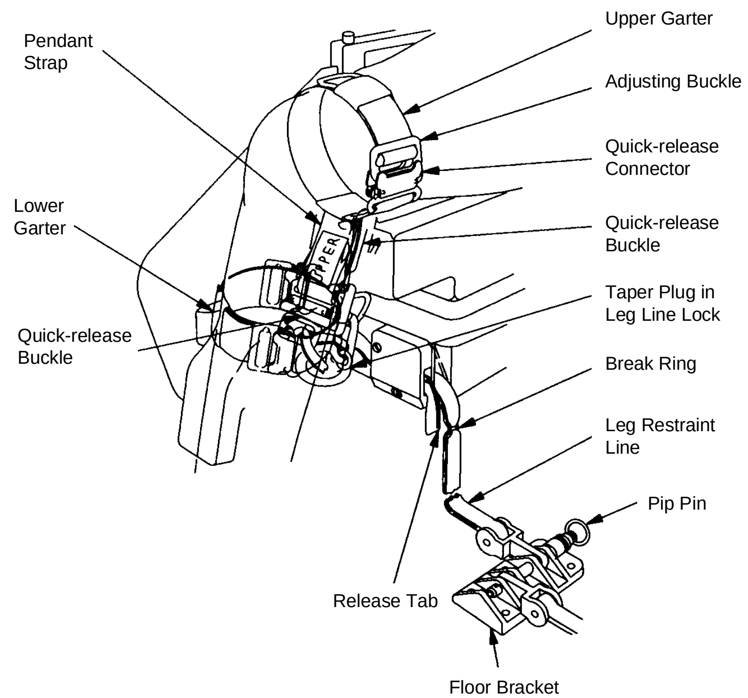


Figure 10: LEG RESTRAINT SYSTEM

Sg 7, fr 20
Fig 10: *Leg Restraint System*

Sg 7, fr 21
Leg Restraint Garters Properly Positioned

B. In The Cockpit

1. Harness and leg restraints

a. Leg restraints - FASTEN AND SECURE LEG RESTRAINT GARTERS

WARNING: The leg restraint lines must be attached to the ejection seat at all times during flight to ensure that the legs will be pulled back upon ejection. This will enhance seat stability and will prevent leg injury by keeping the legs from flailing following ejection.

WARNING: Failure to route the restraint lines properly through the garters could cause serious injury during ejection/ emergency egress.

b. Lap belt - CONNECT AND ADJUST

c. Parachute release fittings - CONNECT

d. Shoulder harness lock lever - CHECK FOR PROPER OPERATION

Sg 6, fr 1
Review Menu

SUMMARY

This lesson has addressed the T-45C canopy and NACES ejection seat, including:

* Canopy shell, frame, cockpit controls/indicators, and the MDC
* Aircraft boarding system
* NACES major components, cockpit controls, and operating characteristics
* Ejection parameters

CONCLUSION

The canopy and ejection seat are critical to ensuring pilot safety in all high-performance jet aircraft. The canopy provides protection from the environment in which you must operate, and the ejection seat allows you to escape a disabled aircraft.

LESSON GUIDE

COURSE/STAGE: TS, ADV & IUT / Engineering

LESSON TITLE: Egress System Malfunctions

LESSON IDENTIFIER: T-45C TS, ADV & IUT ENG-16

LEARNING ENVIRONMENT: CAI

ALLOTTED LESSON TIME: .5 hr

FIGURES:

STUDY RESOURCES:

* T-45C NATOPS Flight Manual, A1-T45AC-NFM-000

LESSON PREPARATION:

Read:

* Part I, Chapter 2.16, "Ejection Seat System," T-45C NATOPS Flight Manual, A1-T45AC-NFM-000

* Part V, Chapter 13, “Ground Emergencies,” and Chapter 17, “Ejection,” T-45C NATOPS Flight Manual, A1-T45AC-NFM-000

Review:

* Lecture Guide for Eng-15, “Egress System”

REINFORCEMENT: N/A

LESSON EXAMINATION:

The student is required to read ingress/egress and related ground emergency paragraphs in the NATOPS flight manual, receive classroom instruction, and complete assigned CAI lesson(s). The student shall demonstrate knowledge by completing, from memory and with 80% accuracy, true/false and multiple choice block examinations. The objectives in this lesson will be tested in either Engineering 29X or Engineering 30X.

LESSON OBJECTIVES

1.5.4.4.1
Identify indications of canopy malfunctions

1.3.5.1.3.4
Identify indications of Command Ejection Selector malfunctions

1.3.5.1.4.3
Identify indications of ejection seat malfunctions

MOTIVATION

This lesson teaches you how to identify several malfunctions with the canopy and ejection seat systems. Recognizing these malfunctions could ensure your safe emergency egress.

OVERVIEW

The goal of this lesson is to give you the background information to recognize canopy and ejection seat systems malfunctions. Some of these malfunctions cause minor inconveniences, but several represent potential life-and-death situations. Treat all malfunctions seriously.

This lesson presents indications of the following canopy and ejection seat systems malfunctions:

* Canopy malfunctions
  - Canopy unlocked
  - Canopy damper locking strut failure
  - MDC fails to shatter canopy
* Command ejection selector failure
* Ejection malfunctions
  - Ejection seat
  - Ejection sequence

REFRESHER

Recall location and function of the:

* Caution advisory panel indications
* Command ejection selector panel switch positions
  - FWD-BOTH/AFT-SELF
  - SOLO
  - BOTH

PRESENTATION

I. Canopy unlocked

A. Indications

1. CANOPY caution light illuminates
2. Canopy control lever may not engage safety catch
3. UNLOCKED decal not fully covered by safety catch
4. Canopy not closed completely
5. When securing aircraft, canopy external handle not in horizontal position
6. Throttle position 95% or above
   a. MASTER ALERT flashes
   b. Caution tone sounds
7. No cabin pressurization, above 5000 ft
8. Noise from improper canopy seal

Fig 1: *Caution Advisory Panel*

Fig 2: *Canopy Control Lever*

B. Verifications

1. On the ground, upward pressure on grab handle moves canopy
2. Open surfaces or FOD between canopy seals and rails
3. Check for cabin altimeter to read same as barometric altimeter above 5000 ft MSL

Fig 3: *Canopy Controls*

C. Effects on flight safety

1. On the ground, canopy cannot be secured--aircraft down
2. No cabin pressurization, restricting altitude capabilities
3. Loss of or damage to canopy and aircraft
4. Possible ejection malfunction

WARNING: Ejection with canopy in any position other than fully closed and locked is not recommended. Serious bodily injury and seat malfunction may occur.

Fig 3: Canopy Controls

II. Canopy damper locking strut failure

A. Indications

1. Upward pressure on grab handle will not lift canopy

2. Upward pressure on canopy external handle will not lift canopy

3. Canopy closes after being lifted open

B. Verifications

1. Front/aft canopy control levers in open position

2. Canopy external handle in open position

C. Effects on safety

1. Delay during emergency ground egress

NOTE: Ground crew may be able to remove canopy damper locking strut assembly pin to release canopy.

2. Possibility of canopy falling on pilots during exit/entry

III. MDC fails to shatter canopy

A. Indications

1. MDC detonation does not occur

2. Canopy fails to fracture

Fig 3: Canopy Controls

B. Verifications: pulling other cockpit MDC firing handle does not shatter canopy

C. Effects on safety: possible delay in ground emergency egress

NOTE: During ground emergency egress, if pulling the MDC firing handles fails to shatter the canopy, egress must be accomplished by opening the canopy with the canopy control lever.

NOTE: If pulling the MDC firing handle fails to shatter the canopy and ejection is necessary, the canopy penetrators will shatter the canopy when ejection is initiated.

WARNING: Ejection with canopy in any position other than fully closed and locked is not recommended. Serious bodily injury and seat malfunction may occur.

IV. Command ejection selector malfunction

A. Indications

1. BOTH

a. Aft seat fails to fire first

b. Either seat ejection handle fails to fire the other seat

2. FWD-BOTH/AFT-SELF

a. Forward ejection handle fails to fire aft ejection seat

b. Aft seat ejection handle fires forward seat

c. Aft and/or fwd handle fails to fire its respective seat

3. SOLO

a. Forward seat ejection handle fires aft seat

b. Forward seat handle fails to fire either seat

B. Verifications: none possible

C. Effects on flight safety

1. Pilot injury from simultaneous or short delay (0.4 seconds normal) ejections

2. Inability to eject other pilot

3. Either seat fails to eject

NOTE: Knowing the ejection modes will enable you to recognize a malfunction and initiate a safe ejection. For example, if the mode selected is BOTH and the front seat initiates ejection, the aft seat should fire automatically. Any other result indicates a malfunction of the command ejection selector.

***Fig 4:** Command Ejection Selector*

Fig 5: Ejection Seat Controls

V. Unable to eject--ejection seat failure

A. Indications

1. Ejection handle jammed

2. Ejection handle fails to fire seat

B. Verifications

Fig 5: Ejection Seat Controls

1. Ensure safety pin removed

2. Ensure safe/armed handle in ARMED position

3. With proper selection of Command Ejection Selector control, other seat ejection handle fails to fire seat

4. MDC does not shatter canopy

C. Effects on flight safety: ejection and bailout impossible

WARNING: There is no manual bailout capability with this ejection seat.

VI. Ejection sequence malfunction

A. Indications

1. Drogue chute fails to deploy

NOTE: Approximately four seconds after a high altitude ejection, the drogue chute should stabilize the seat from tumbling.

2. Seat fails to separate from pilot

NOTE: Seat/man separation is controlled by the electronic sequencer with the barostatic unit as a backup. The operational window for the system is established at 18,000 ft MSL.

WARNING: If high terrain is not a factor, do not use manual seat/man separation until below 14,000 feet MSL.

B. Verifications: none possible

Fig 5: Ejection Seat Controls

NOTE: To initiate a manual separation, pull the emergency restraint release handle.

C. Effects on flight safety: possible disorientation and injury due to tumbling

SUMMARY

This lesson has presented indications of the following canopy and ejection seat systems malfunctions:

* Canopy malfunctions
  - Canopy unlocked
  - Canopy damper locking strut failure
  - MDC fails to shatter canopy
* Command ejection selector malfunctions
* Ejection malfunctions
  - Ejection seat
  - Ejection sequence

CONCLUSION

Being able to recognize canopy and ejection seat systems malfunctions quickly is critical to making safe and logical decisions in an emergency. The conditions described in this lesson might occur in conjunction with each other or with some malfunction related to another aircraft system. Your safety depends on your ability to evaluate a malfunction correctly and act accordingly.

If this lesson has raised any questions for you, be certain to contact your instructor.

FIGURES

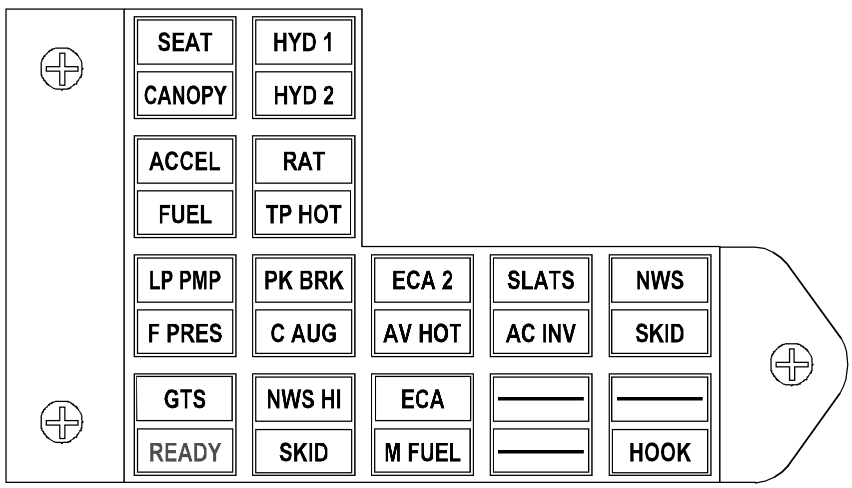


Figure 1: CAUTION ADVISORY PANEL

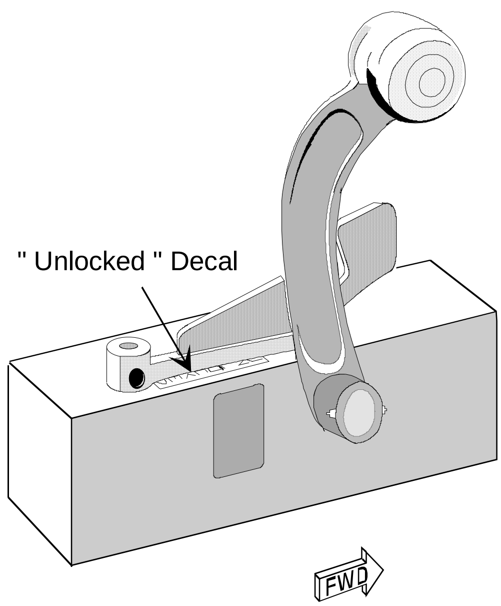


Figure 2: CANOPY CONTROL LEVER

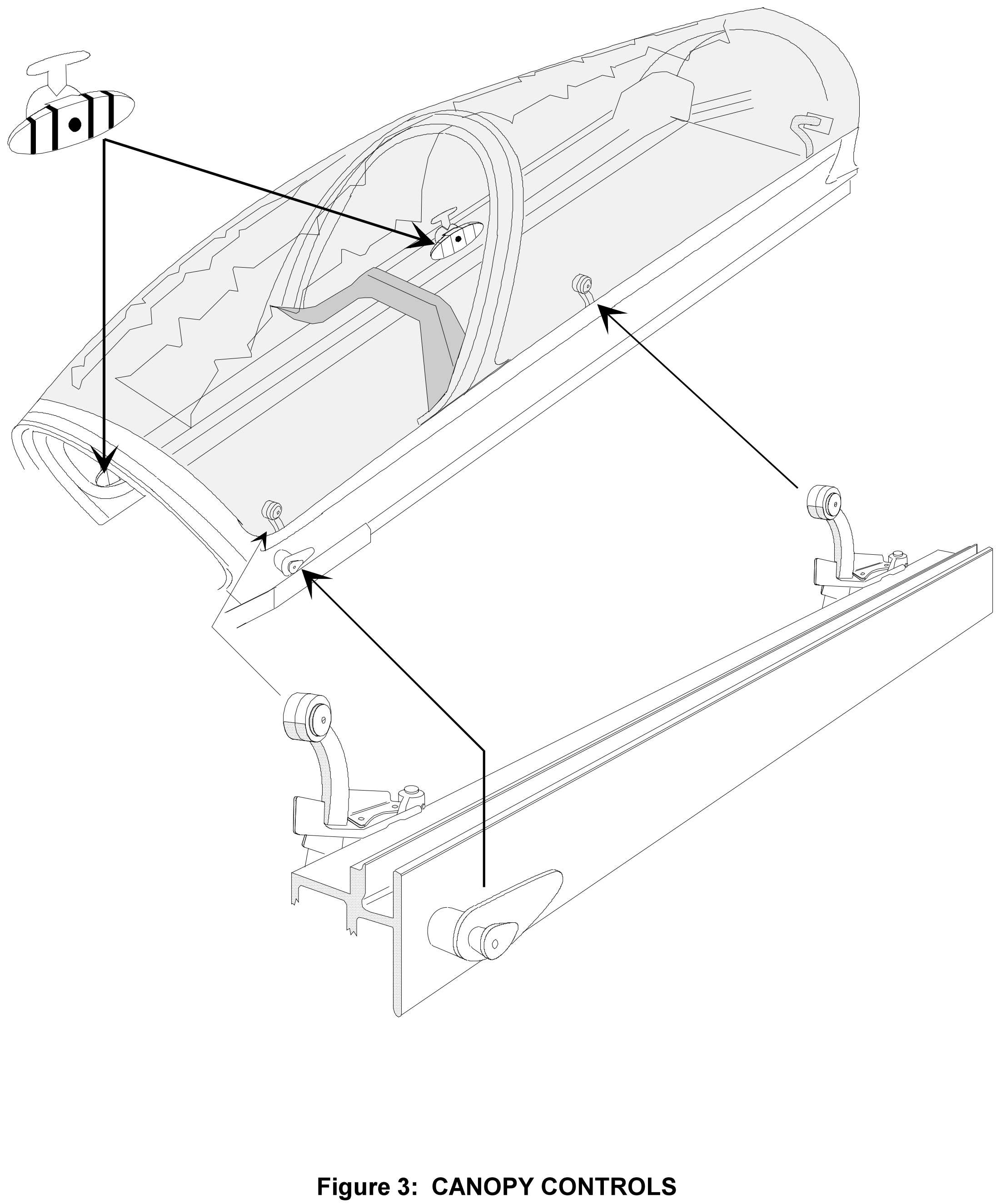


Figure 3: CANOPY CONTROLS

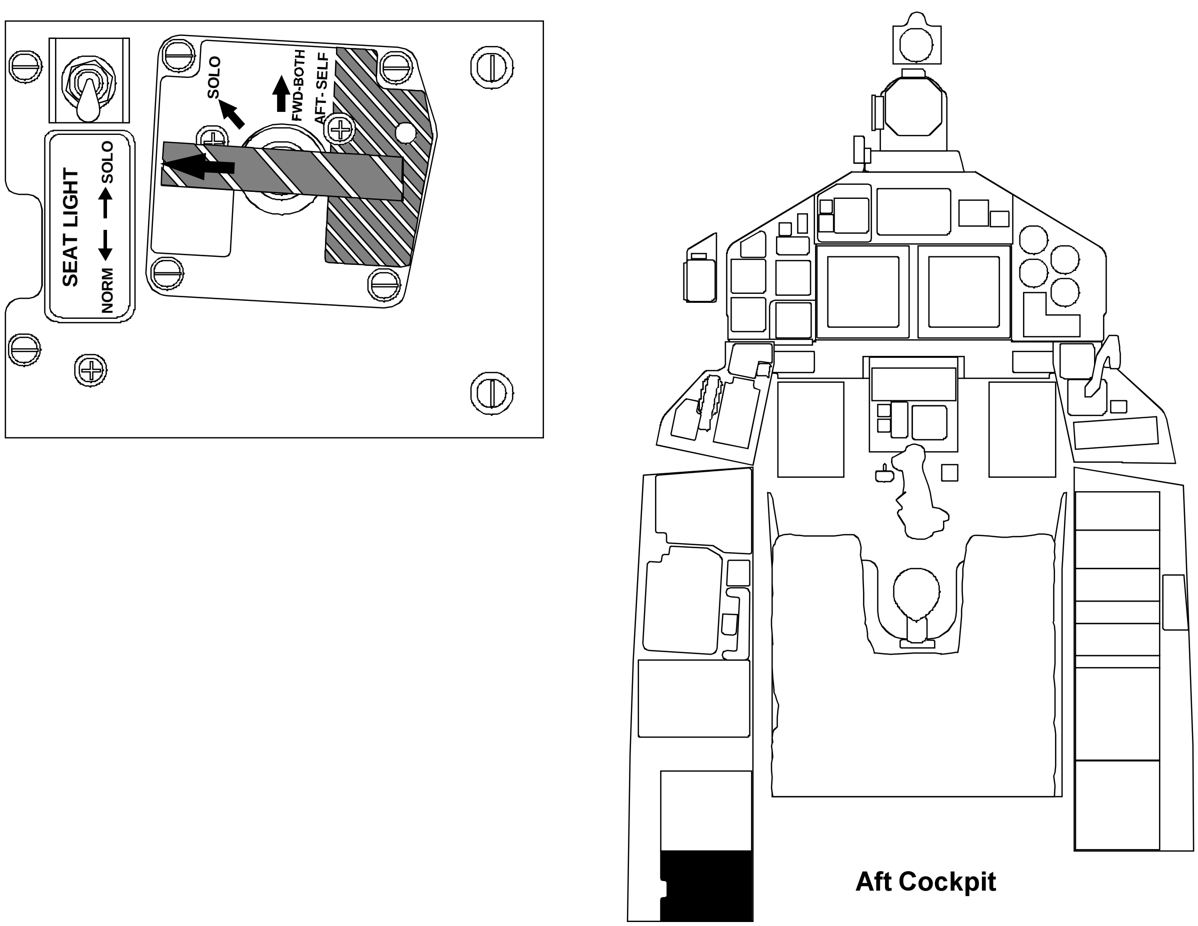


Figure 4: COMMAND EJECTION SELECTOR

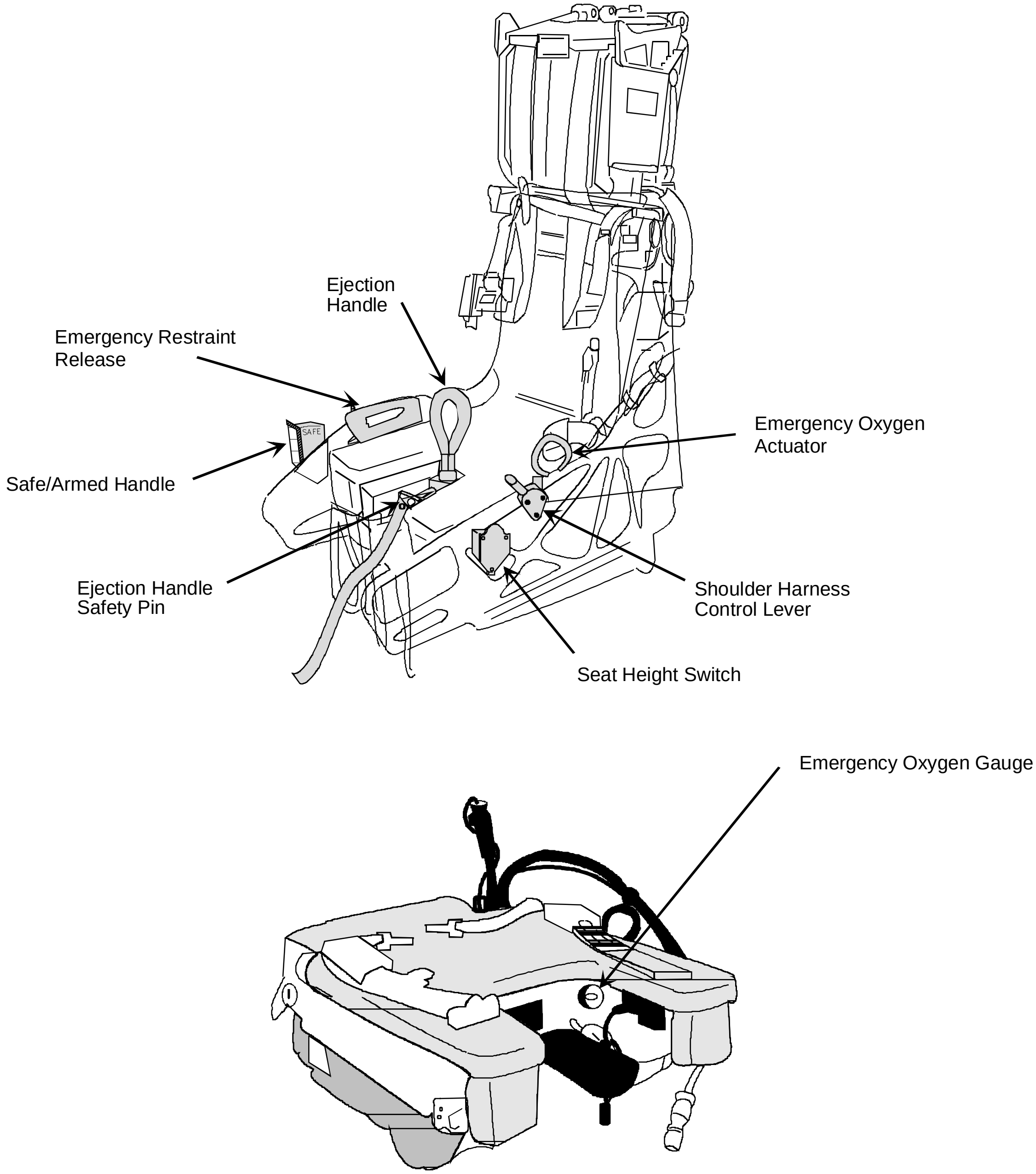


Figure 5: EJECTION SEAT CONTROLS

LECTURE GUIDE

COURSE/STAGE: TS, ADV & IUT / Engineering

LESSON TITLE: OBOGS & ECS/Pressurization System

LESSON IDENTIFIER: T-45C TS, ADV & IUT ENG-17

LEARNING ENVIRONMENT: Classroom

ALLOTTED LESSON TIME: 0.9 hr

TRAINING AIDS:

* Figures
  Fig 1: OBOGS Flow
  Fig 2: Environmental Control System

STUDY RESOURCES:

* T-45C NATOPS Flight Manual, A1-T45AC-NFM-000

LESSON PREPARATION:

Read:

* Part I, Chapter 2, Sections 2.18, "Environmental Control System," and 2.19, "On-Board Oxygen Generating System," in the T-45C NATOPS Flight Manual, A1-T45AC-NFM-000

REINFORCEMENT: N/A

EXAMINATION:

The student is required to read On-Board Oxygen Generating System/Anti-G and Environmental Control System and related malfunction paragraphs in the NATOPS flight manual, receive classroom instruction, and complete assigned CAI lesson(s). The student shall demonstrate knowledge by completing, from memory with 80% accuracy, true/false and multiple choice block examinations. The objectives in this lesson will be tested in either Engineering 29X or Engineering 30X.

LESSON OBJECTIVES

1.4.16.3.1
Recall major components of the OBOGS

1.4.16.2.1
Recall operating characteristics of the OBOGS

1.4.16.3
Recall function, purpose, and location of the OBOGS controls, switches, and indicators

1.4.16.1.1
Recall operational check requirements for the OBOGS

1.4.16.2
Recall interfaces between the OBOGS and other a/c systems

1.4.15.3.1
Recall major components of the ECS

1.4.15.2.1
Recall operating characteristics of the ECS

1.4.15.3
Recall function, purpose, and location of the ECS controls, switches, and indicators

1.4.15.2
Recall interfaces between the ECS and other a/c systems

MOTIVATION

Due to the high altitude environment in which you will be flying the T-45C, you must know how to use the on-board oxygen generating system (OBOGS) and environmental control system (ECS) to accomplish a successful and safe flight.

OVERVIEW

After this lesson, you will understand the OBOGS and ECS and how to operate them effectively.

In this lesson we will be covering the:

* Major components of the OBOGS
* Operational characteristics of the OBOGS
* Function, purpose, and location of OBOGS controls, switches, and indicators
* Operational check requirements for the OBOGS
* Interfaces between OBOGS and other a/c systems
* Major components of the ECS
* Operational characteristics of the ECS
* Function, purpose, and location of ECS controls, switches, and indicators
* Interfaces between ECS and other a/c systems

PRESENTATION

Sg 1, fr 2
Lesson Organization

OBOGS/SYSTEM

* Major OBOGS components
* OBOGS operating characteristics
* OBOGS controls, switches, and indicators
* OBOGS operational check requirements
* OBOGS aircraft interfaces
* Major ECS components
* ECS operating characteristics
* ECS controls, switches, and indicators
* ECS aircraft interfaces

I. Major OBOGS components **1.4.16.3.1**

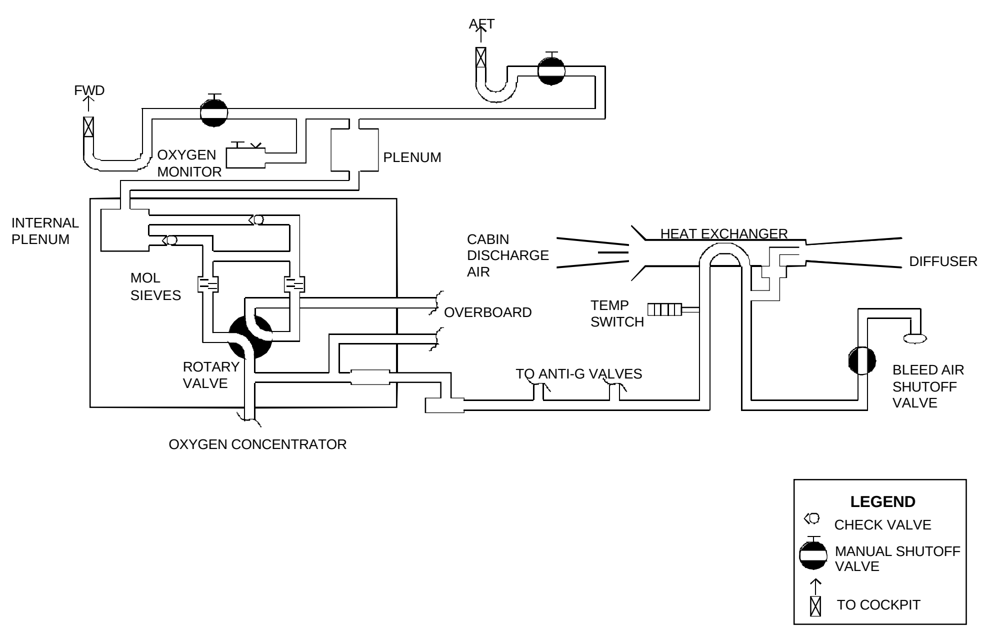


Figure 1: OBOGS FLOW

Sg 1, fr 3
(5 overlays)
Fig 1: *OBOGS Flow*

A. OBOGS bleed air shutoff valve: located on upper left side of fifth-stage engine compressor

Overlay 1
Heat Exchanger

B. Heat exchanger: located on auxiliary equipment rack, aft of rear cockpit

Overlay 2
Temperature switch

C. Temperature switch: located in auxiliary compartment, aft of rear cockpit

Overlay 3
Oxygen Concentrator

D. Oxygen concentrator: located in nose equipment compartment

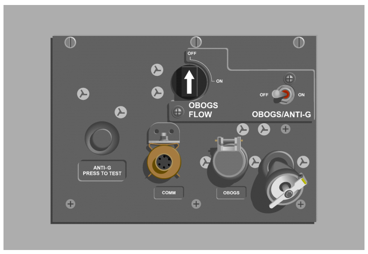
Overlay 4
Plenum

E. Plenum: located between cockpits, below and forward of aft cockpit rudder pedals

Overlay 5
Oxygen Monitor

F. Oxygen monitor: located left side of fwd ejection seat bulkhead

Sg 1, fr 9
Pilot Services Panel



Sg 2, fr 2
Lesson Organization

OBOGS/SYSTEM

* Major OBOGS components
* OBOGS operating characteristics
* OBOGS controls, switches, and indicators
* OBOGS operational check requirements
* OBOGS aircraft interfaces
* Major ECS components
* ECS operating characteristics
* ECS controls, switches, and indicators
* ECS aircraft interfaces

Sg 2, fr 3 (9 overlays)
Fig 1: OBOGS Flow

Overlay 1
OBOGS Bleed Air Shutoff Valve

Overlay 2
Heat Exchanger

G. Ejection seat (oxygen/communications hose): both cockpits

H. Pilot's personal gear

1. Chest-mounted oxygen regulator

2. Oxygen mask

3. Anti-g suit

I. Pilot services panel: located left console, both cockpits

NOTE: The OBOGS/ANTI-G switch is only on the FWD pilot services panel.

II. OBOGS operating characteristics **1.4.16.2.1**

A. Functional description: OBOGS converts engine compressor bleed air to oxygen-enriched breathing air at the correct pressure and temperature. It uses fifth stage compressor air from the OBOGS bleed air port.

1. OBOGS bleed air shutoff valve

a. Controls supply of engine compressor air required to operate OBOGS

b. Controlled by temperature switch

c. Receives logic control signals from OBOGS/ ANTI-G switch and overheat temperature sensor

d. Directs bleed air to heat exchanger

2. Heat exchanger

a. Receives bleed air from bleed air shutoff valve

b. Reduces temperature of bleed air to level compatible with oxygen concentrator for optimum performance

c. Pulls cool ambient (cabin discharge) air across core to absorb heat before being exhausted overboard through diffuser duct

d. Some engine compressor bleed air is directed through the filtered ejector nozzle in the heat exchanger and exhausted through the mixer/ diffuser duct. This action creates suction to pull compartment air across the heat exchanger.

e. Routes cooled air to overheat temperature sensor

3. Overheat temperature switch/sensor

Overlay 3
Overheat Temperature Switch/Sensor

a. Monitors bleed air temperature from heat exchanger

b. When switch/sensor detects temperature greater than 250 degrees F at any altitude:

(1) Provides signal to OXYGEN warning light on warning panel

4. Oxygen concentrator

Overlay 4
Oxygen Concentrator

a. Receives cooled air from heat exchanger

b. Filters nitrogen and other contaminants from cooled engine bleed air, producing oxygen-enriched air for pilots

(1) Cooled engine bleed air from heat exchanger passes through inlet filter and pressure reducer in the oxygen concentrator to the rotary valve.

Overlay 5
Rotary Valve

(2) Rotary valve directs air to one of two molecular sieve beds alternately every five seconds

Overlay 6
Molecular Sieves

(3) Sieve bed filters out nitrogen and contaminants and directs oxygen-rich air to internal plenum

Overlay 7
Internal Plenum

(4) Internal plenum receives oxygen-rich breathing air from both sieve beds and directs air to oxygen plenum

c. Directs oxygen-rich breathing air to plenum

Overlay 8
Plenum

5. Plenum

a. Receives oxygen from concentrator

b. Provides a volume of oxygen-enriched breathing air to meet peak demands

c. Prevents surges in pilots'oxygen supply

d. Equalizes temperature of breathing air from concentrator to cockpit

e. Passes oxygen to oxygen/communications hose quick-disconnects

Overlay 9
Oxygen Monitor

6. Oxygen monitor

a. Provides BIT using cockpit air

b. Continuously analyzes oxygen-enriched breathing air

c. Senses low oxygen concentrations

(1) Activates MASTER ALERT

(2) Sounds warning tone

(3) Illuminates OXYGEN warning light on warning panel

d. Provides rapid warmup (via built-in circuit heater) during low outside temperature

7. Ejection seat: manifold provides common duct for OBOGS and emergency oxygen system

8. Pilot's personal gear

   a. Regulator

      (1) Delivers oxygen-enriched air at positive pressure before reaching face mask

      (2) Increases pressure automatically at cabin altitudes above 35,000 ft

   b. Face mask: delivers oxygen-enriched air to pilot

   c. Anti-g suit: receives pressure via operating air from OBOGS air supply duct through g valve--pressure is regulated based on the following conditions

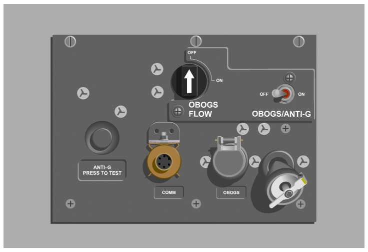
      (1) Increasing positive g forces move activating weight down compressing a spring, opening demand valve and initiating inflation of g suit at approximately 2 g

      NOTE: Maximum inflation occurs at approximately 6 g

      (2) Decreasing g forces allow spring tension to move activating weight up, opening exhaust valve and deflating g suit

9. Pilot services panel (left console, both cockpits)

   Sg 2, fr 14
   Pilot Services Panel



   a. Provides immediate connection/disconnection of oxygen hose to ejection seat

   b. Enables manual opening/closing of bleed air shutoff valve

   c. Enables/disables OBOGS flow of oxygen-enriched air to seat survival kit

   d. Provides a built-in-test capability (anti-g system)

e. Provides immediate connect/disconnect to anti-g hose

PROGRESS CHECK

Question 1 — 1.4.16.2.1
Where in the OBOGS are the nitrogen and contaminants removed from the compressor air?

ANSWER: In the oxygen concentrator molecular sieves

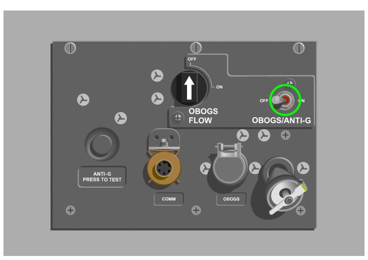
__Sg 3, fr 2__
Lesson Organization

OBOGS/SYSTEM

* Major OBOGS components
* OBOGS operating characteristics
* OBOGS controls, switches, and indicators
* OBOGS operational check requirements
* OBOGS aircraft interfaces
* Major ECS components
* ECS operating characteristics
* ECS controls, switches, and indicators
* ECS aircraft interfaces

III. OBOGS controls, switches, and indicators **1.4.16.3**

__Sg 3, fr 3 (4 overlays)__
Pilot Services Panel



A. Pilot services panel

1. OBOGS/ANTI-G switch (fwd cockpit only)

a. ON: turns on OBOGS and anti-g system

b. OFF: closes bleed air shutoff valve to turn off OBOGS/anti-g system and illuminates the OXYGEN warning light

__Overlay 1__
OBOGS FLOW Selector

2. OBOGS FLOW selector

a. OFF: shuts off oxygen flow to oxygen mask

b. ON: permits oxygen flow to oxygen mask

__Overlay 2__
OBOGS Hose Connector

3. OBOGS hose connector: provides connection for ejection seat survival kit

__Overlay 3__
ANTI-G Suit Connector

4. ANTI-G suit connection: quick disconnect receptacle for anti-g suit

__Overlay 4__
ANTI-G PRESS TO TEST Button

5. ANTI-G PRESS TO TEST button: when pressed and held, directs flow of air into anti-g suit for purpose of checking anti-g system operation or for providing body massage

NOTE: The anti-g system is automatically activated when the OBOGS/ANTI-G switch is set to ON.

B. OXYGEN warning light: indicates the OBOGS/ANTI-G switch is OFF or OBOGS failure when illuminated--either low oxygen concentration in the system supply or bleed air temperature exceeds 250 degrees F

C. Oxygen monitor (fwd cockpit only): continuously samples oxygen-enriched air for proper concentration level

D. OBOGS Pneumatic BIT button (fwd cockpit only): when pressed and held, activates BIT operation. Releasing button deactivates BIT circuit. The pneumatic BIT button can be rotated when pressed, locking the button in the BIT position. (This is intended for maintenance use.)

Warning: Testing the OBOGS above 9000 feet shuts down the OBOGS.

PROGRESS CHECK

Question 2 — 1.4.16.3.1
Where is the oxygen monitor located?

ANSWER: Left side of fwd ejection seat bulkhead

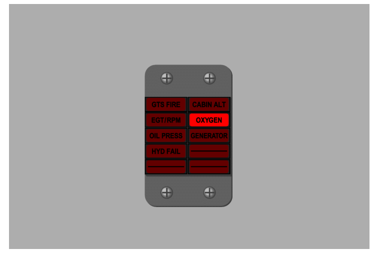
Question 3 — 1.4.16.3
Which control enables/disables the oxygen-enriched airflow to each mask?

ANSWER: The OBOGS FLOW selector

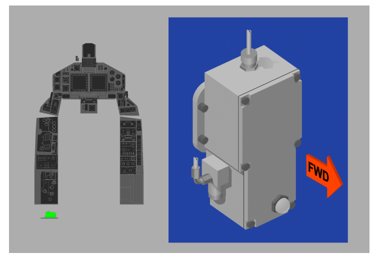
Question 4 — 1.4.16.3
What is the name of the control used to inflate the g suit and where is it located?

ANSWER: The ANTI-G PRESS TO TEST button is located on the pilot services panel.

Sg 3, fr 8
OXYGEN Warning Light



Sg 3, fr 9 (1 overlay)
Oxygen Monitor



Overlay 1
OBOGS BIT Button

Sg 7, fr 2
Lesson Organization

OBOGS/SYSTEM

* Major OBOGS components
* OBOGS operating characteristics
* OBOGS controls, switches, and indicators
* OBOGS operational check requirements
* OBOGS aircraft interfaces
* Major ECS components
* ECS operating characteristics
* ECS controls, switches, and indicators
* ECS aircraft interfaces

IV. OBOGS operational check requirements **1.4.16.1.1**

LESSON NOTES

Because preflight checks and services will be covered in detail in later blocks (CO, Fam), they will only be introduced here.

A. Preflight checks

NOTE: The following italicized steps on preflight checks and services are excerpted from NATOPS.

1. Exterior inspection

a. Nose section

(1) Ram air inlet - CONDITION

2. Entering cockpit

a. Aft cockpit (solo flight)

(1) OBOGS FLOW selector - OFF

3. In The Cockpit

a. Oxygen and G-suit leads - CONNECT

4. Interior check

a. Forward Cockpit

(1) OBOGS FLOW selector - OFF

(2) OBOGS/ANTI-G switch - OFF

(3) CABIN pressure altimeter - CHECK

(4) Cockpit air conditioning - NORMAL/AS DESIRED

b. Aft Cockpit

(1) OBOGS FLOW selector - OFF

(2) CABIN pressure altimeter - CHECK

5. Starting Engine

a. OBOGS/ANTI-G switch-ON

6. Poststart

a. OBOGS pneumatic BIT button - PRESS Hold until OXYGEN warning light illuminates. Ensure light goes out 1 minute after releasing button

b. Oxygen mask - ON/CONFIRM FLOW

c. ANTI-G test button - PRESS

B. Evaluation criteria

1. When the OBOGS pneumatic test button is pressed, cockpit air enters oxygen monitor illuminating the OXYGEN warning light. The OXYGEN warning light should illuminate within 65 seconds and extinguish within 1 minute of releasing the button

NOTE: Due to the extreme sensitivity of the pneumatic BIT mechanism, steady uninterrupted manual pressure on the BIT button is required to obtain a satisfactory test.

2. Wearing oxygen mask not required during oxygen test but will speed up testing process

V. OBOGS aircraft interfaces **1.4.16.2**

A. Electrical

1. 28 VDC essential services bus provides power

a. OBOGS concentrator/monitor

Sg 11, fr 2
Lesson Organization

OBOGS/SYSTEM

* Major OBOGS components
* OBOGS operating characteristics
* OBOGS controls, switches, and indicators
* OBOGS operational check requirements
* OBOGS aircraft interfaces
* Major ECS components
* ECS operating characteristics
* ECS controls, switches, and indicators
* ECS aircraft interfaces

b. Bleed valve control

2. 28 VDC generator bus provides power to the OBOGS heater

B. Engine

1. Fifth-stage bleed air

a. OBOGS

b. Anti-g

C. Centralized warning system (CWS) outputs: OXYGEN Warning light

VI. Major ECS components **1.4.15.3.1**

Sg 4, fr 2
Lesson Organization

OBOGS/SYSTEM

* Major OBOGS components
* OBOGS operating characteristics
* OBOGS controls, switches, and indicators
* OBOGS operational check requirements
* OBOGS aircraft interfaces
* Major ECS components
* ECS operating characteristics
* ECS controls, switches, and indicators
* ECS aircraft interfaces

Sg 4, fr 3
(10 overlays)
Fig 2: *Environmental Control System*

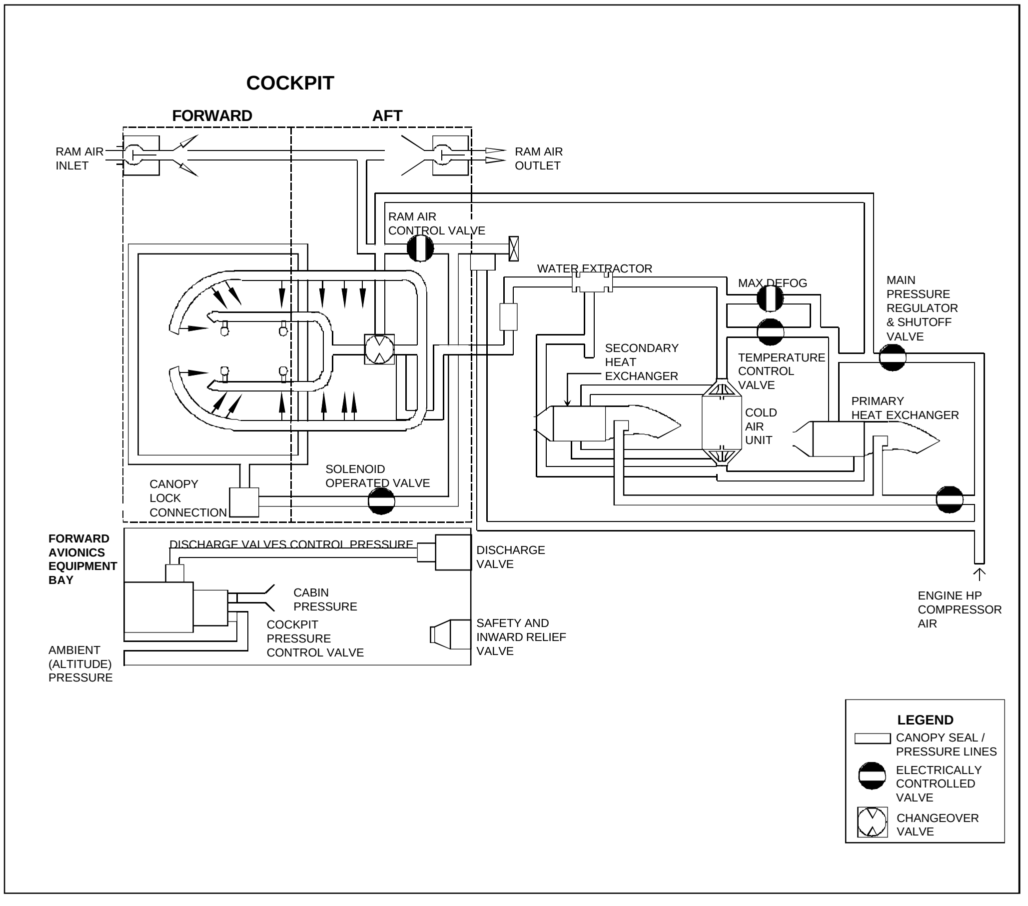


Figure 2: ENVIRONMENTAL CONTROL SYSTEM

A. Air conditioning system--major components

1. Main pressure regulating and shutoff valve (MPRSOV): located top of fuselage, aft of canopy

2. Primary heat exchanger: located top of fuselage, aft of canopy

3. Inducer pressure regulating and shutoff valve (IPRSOV): located top of fuselage, aft of canopy

4. Cold air unit (CAU): located top of fuselage, aft of canopy, consists of two primary components--compressor and turbine

5. Secondary heat exchanger: located top of fuselage, aft of canopy

6. Temperature control valve: located top of fuselage, aft of canopy

7. Water extractor: located top of fuselage, aft of canopy

8. Crew ventilation ducts: located under left and right canopy rails

9. Defog ducts: located at left and right base of the windshield and canopy

10. Ram air intake valves: located on top of nose cone

11. Ram air outlet valves: located on the cockpit forward and aft bulkheads

B. Cockpit pressurization system--major components

1. Pressure control valve: located on fwd cockpit bulkhead behind instrument panel

2. Discharge valves (2): one collocated with the pressure control valve, the other aft cockpit on bulkhead behind seat

Overlay 1
Primary Heat Exchanger

Overlay 2
IPRSOV

Overlay 3
CAU

Overlay 4
Secondary Heat Exchanger

Overlay 5
Temperature Control Valve

Overlay 6
Water Extractor

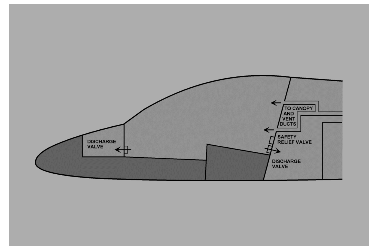
Overlay 7
Crew Ventilation Ducts

Overlay 8
Defog Ducts

Overlay 9
Ram Air Intake Valves

Overlay 10
Ram Air Outlet Valves

Sg 4, fr 14
(2 overlays)
Cockpit Pressurization System - Simplified



Overlay 1
Discharge Valves

Overlay 2
Safety Relief Valve

3. Safety relief valves: located on cockpit bulkhead

4. Canopy seal: cemented to the seal retaining channel which surrounds the canopy

C. Avionics equipment cooling system--major components

1. Pressure control valve: located on fwd cockpit bulkhead behind instrument panel

2. Discharge valves (2): one collocated with the pressure control valve, the other aft cockpit on bulkhead behind seat

Sg 5, fr 2
Lesson Organization

OBOGS/SYSTEM

* Major OBOGS components
* OBOGS operating characteristics
* OBOGS controls, switches, and indicators
* OBOGS operational check requirements
* OBOGS aircraft interfaces
* Major ECS components
* ECS operating characteristics
* ECS controls, switches, and indicators
* ECS aircraft interfaces

VII. ECS operating characteristics **1.4.15.2.1**

Sg 5, fr 3 (11 overlays)
Fig 2: *Environmental Control System*

A. Air conditioning system: the ECS system taps air from a fifth-stage bleed air port. Airflow through the air conditioning system is controlled by a solenoid-operated main pressure regulator and shutoff valve (MPRSOV)

Overlay 1
MPRSOV

1. MPRSOV

a. Divides airflow into two separate paths

(1) Cold airflow path directs air through the air conditioning system for cooling

(2) Hot airflow path

(a) Air conditioning system bypassed

(b) Amount of air bypassed is varied by cockpit temperature control knob setting

Overlay 2
Primary Heat Exchanger

2. Primary heat exchanger

a. Receives bleed air from fifth-stage engine compressor ECS port

b. Reduces temperature of engine compressor bleed air before passing it to cold air unit (CAU)

3. Inducer pressure regulator and shutoff valve (IPRSOV): controls airflow to the inducers

Overlay 3
IPRSOV

   a. When the landing gear is extended, cooling air is inducted through each heat exchanger by a cooling air jet pump (inducer)

   b. When either the landing gear is raised or the cockpit air conditioning system is switched off, the inducers will shut off

      (1) Inducer shutoff valve: compensates for lack of airflow through primary and secondary heat exchangers at slow airspeed when gear down

4. CAU compressor: compresses bleed air received from primary heat exchanger

Overlay 4
CAU Compressor

5. Secondary heat exchanger: dissipates heat gained during compression by CAU compressor

Overlay 5
Secondary Heat Exchanger

6. CAU turbine

Overlay 6
CAU Turbine

   a. Further cools air received from secondary heat exchanger by expansion through turbine

   b. Airflow through the turbine drives the CAU compressor

7. Temperature control valve: controls final conditioned air temperature by mixing cold air from CAU turbine with hot airflow path from MPRSOV

Overlay 7
Temperature Control Valve

8. Water extractor: reduces water content of air distributed to cockpit air distribution and canopy defog systems

Overlay 8
Water Extractor

   a. Water is drained to inlet duct of secondary heat exchanger

9. Cockpit air distribution

    a. Receives conditioned air from air conditioning pack

Overlay 9
Crew Ventilation Ducts

    b. Temperature-controlled air distributed to crew ventilation ducts and head, body, and foot louvers

    c. Ram air and inducer shutoff valves operate automatically by proximity switches on landing gear

        (1) Ram air valve: closes during normal operation when weight-on-wheels (WOW) switch senses that aircraft is airborne

Overlay 10
Defog Ducts

10. Canopy defog

    a. Receives conditioned air from air conditioning system and engine compressor air during maximum defog

    b. Distributes conditioned air through canopy defogging ducts

Overlay 11
Ram Air

11. Ram air ventilation

    a. Inlet/outlet valves operated by air pressure from canopy seal system

    b. Admits air into forward cockpit

    c. Expels used air through ram air outlet valve in aft cockpit

    d. Controlled automatically via WOW switch

        (1) Ground (weight-on-wheels): opens ram air valves automatically on touchdown when air conditioning system switch is in NORMAL, DEFOG, or MAX DEFOG position

(2) Airborne (weight-off-wheels): with air conditioning set to OFF, ram air valves open, providing emergency ventilation

B. Cockpit pressurization system

1. General

a. Pressurization commences with weight-off-wheels

b. Pressurization increases linearly until attaining full differential pressure of 4 psi at 40,000 ft MSL

NOTE: Cabin altitude may be as much as 2,000 ft below aircraft altitude from MSL up to an aircraft altitude of 5,000 ft.

c. Provides signal to CABIN ALT warning light if cockpit altitude exceeds 24,500 +/- 500 ft MSL

2. Pressure control valve: maintains cockpit pressure at predetermined value with respect to aircraft altitude

3. Discharge valves: control cockpit pressurization by adjusting airflow out of the cockpit in response to control inputs from the pressure control valve

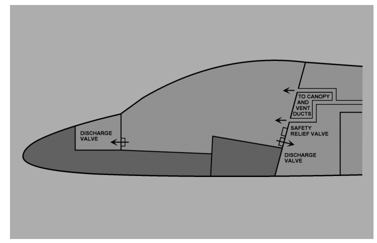
4. Safety relief valve: ensures that positive cockpit pressure does not exceed 4.8 psi and that inward negative cockpit differential pressure does not exceed 0.5 psi

C. Avionics equipment cooling system

1. While airborne, some of the conditioned cockpit air exhausted through the discharge valves passes through the avionics compartments on its way to being discharged overboard

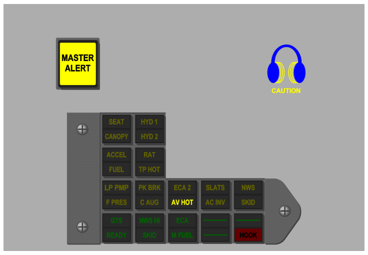
2. On the ground with the canopy open, the diverter valve directs ECS cooling air from the canopy defog vents to the avionics compartments

Sg 5, fr 15
(3 overlays)
Cockpit Pressurization System



Overlay 1
Discharge Valve Operation
Overlay 2
Cockpit Pressurization
Overlay 3
Safety Valve Operation

Sg 5, fr 19
AV HOT Caution Light

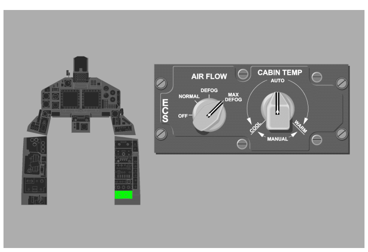


Sg 6, fr 2
Lesson Organization

OBOGS/SYSTEM

* Major OBOGS components
* OBOGS operating characteristics
* OBOGS controls, switches, and indicators
* OBOGS operational check requirements
* OBOGS aircraft interfaces
* Major ECS components
* ECS operating characteristics
* ECS controls, switches, and indicators
* ECS aircraft interfaces

Sg 6, fr 3
Air Conditioning Control Panel



Overlay 1
Air Conditioning Control Knob

Overlay 2
Cockpit Temperature Control Knob

NOTE: Closing the canopy diverts ECS air from avionics cooling to the defog vents.

3. The AV HOT caution light only operates on the ground and will illuminate if the air temperature in the avionics cooling ducts exceeds 67 degrees C (153 degrees F)

VIII. ECS controls, switches and indicators **1.4.15.3**

A. Air conditioning system

1. Air conditioning control panel (fwd cockpit only)

a. Cockpit air conditioning knob

(1) OFF: energizes solenoid to close main pressure regulating and shutoff valve (MPRSOV). Ram air ventilation is automatically activated

(2) NORMAL: opens MPRSOV and IPRSOV (if landing gear extended) to provide air conditioning and pressurization by directing approximately 60% of the airflow to the crew ventilation ducts and 40% to defog ducts

(3) DEFOG: Diverts approximately 60% of the airflow to the windshield and canopy defog ducts and 40% to crew ventilation ducts

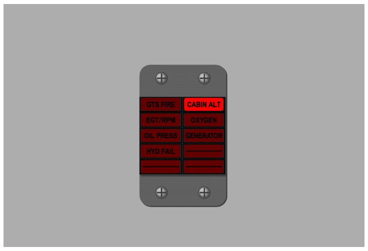
(4) MAX DEFOG: Opens max defog valve to allow additional supply of hot air mixing with cold airflow

b. Cockpit temperature control knob

(1) AUTO: cockpit temperature automatically controlled by positioning the knob toward COOL or WARM position to maintain desired cockpit temperature setting

(2) MANUAL (spring-loaded to center): cockpit temperature is manually controlled by positioning and holding knob at desired COOL or WARM position (6-12 seconds from full cold to full hot and vice versa)

Sg 6, fr 5
CABIN ALT Warning Light



2. CABIN ALT warning light: Indicates air conditioning system failure caused by overpressure to CAU compressor, CAU compressor outlet temperature above 500 degrees F, CAU turbine inlet temperature above 250 degrees F, or cockpit pressurization failure when CABIN pressure altimeter indication exceeds 24,500 +/- 500 feet

B. Cockpit pressurization system

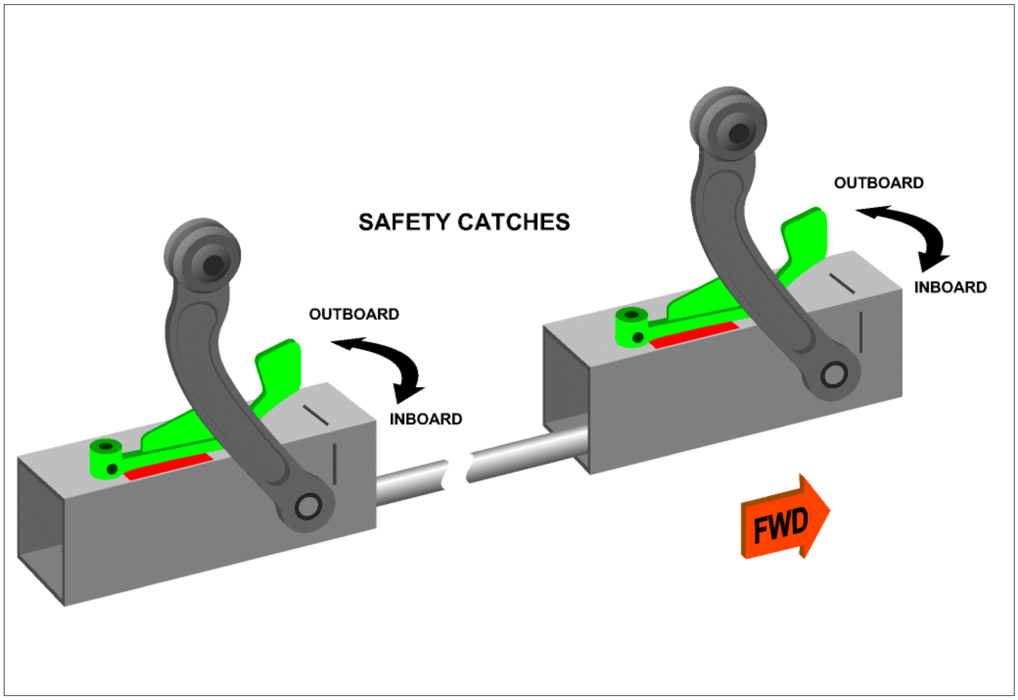


Fig 3: Canopy Safety Catches

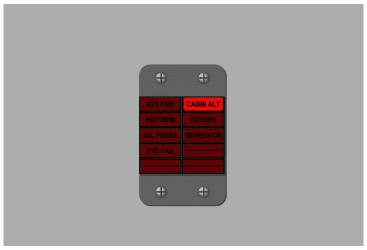
Sg 6, fr 6
Fig 3: *Canopy Safety Catches*

1. Canopy control lever safety catch

   a. Press outboard: deflates canopy seal

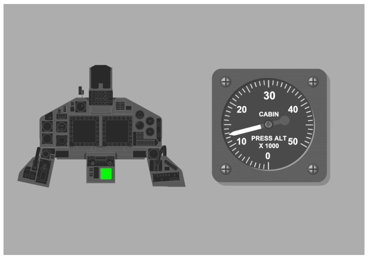
   b. Close: Inflates canopy seal if the canopy is closed

Sg 6, fr 7
CABIN ALT Warning Light



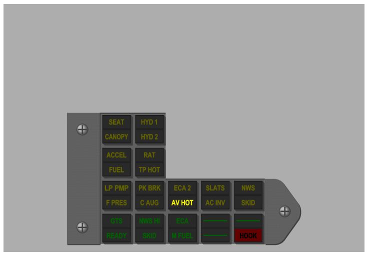
2. CABIN ALT warning light: indicates cockpit pressurization failure. Illuminates when cabin pressure altimeter exceeds 24,500 +/- 500 feet indication

Sg 6, fr 8
Cabin Pressure Altimeter



3. Cabin pressure altimeter: Indicates cockpit pressure altitude

Sg 6, fr 9
AV HOT Caution Light



C. Avionics equipment cooling system: AV HOT caution light illuminates when air temperature in avionics cooling air duct exceeds 67 degrees C (153 degrees F). Light illuminates only when the aircraft is on the ground

NOTE: In the event of an AV HOT caution light, opening the canopy will redirect ECS air from defog to the avionics.

PROGRESS CHECK

Question 5 — 1.4.15.3.1
Of what three subsystems does the ECS system consist?

ANSWERS:
1. Air conditioning
2. Pressurization
3. Avionics equipment cooling

Question 6 — 1.4.15.3
What is indicated by the illumination of the CABIN ALT warning light?

ANSWER: Cockpit pressurization or air conditioning failure. Light illuminates when cabin pressure altimeter exceeds 24,500 +/- 500 ft indication, overpressure to CAU compressor, CAU outlet temperature above 500 degrees F, or CAU turbine inlet temperature above 250 degrees F.

IX. ECS aircraft interfaces **1.4.15.2**

A. Electrical inputs

1. 28 VDC essential services bus

   a. Cockpit air conditioning control

   b. Cabin pressure control 1

   c. Cabin pressure warning

2. 28 VDC generator bus: cabin pressure control 2

B. Engine inputs: fifth-stage bleed air

1. Cockpit air conditioning

   a. Defog

   b. Temperature control

2. Pressurization system

3. Avionics cooling system

4. Ram air vent system control

C. Centralized warning system (CWS) outputs

1. CABIN ALT warning light

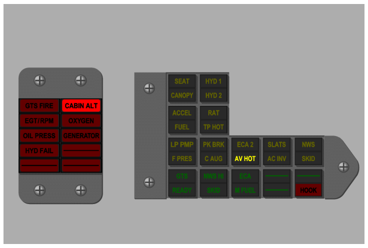
2. AV HOT caution light

Sg 8, fr 2
Lesson Organization

OBOGS/SYSTEM

* Major OBOGS components
* OBOGS operating characteristics
* OBOGS controls, switches, and indicators
* OBOGS operational check requirements
* OBOGS aircraft interfaces
* Major ECS components
* ECS operating characteristics
* ECS controls, switches, and indicators
* ECS aircraft interfaces

Sg 8, fr 3
Warning and Caution Advisory Light Panels



Sg 10, fr 1
Review Menu

SUMMARY

This lesson has covered the:

* Major components of the OBOGS
* Operational characteristics of the OBOGS
* Function, purpose, and location of OBOGS controls, switches, and indicators
* Operational check requirements for the OBOGS
* Interfaces between OBOGS and other a/c systems
* Major components of the ECS
* Operational characteristics of the ECS
* Function, purpose, and location of ECS controls, switches, and indicators
* Interfaces between ECS and other a/c systems

CONCLUSION

OBOGS/ECS are the primary life support systems on the T-45C aircraft. Knowing how to operate them properly and how to analyze any malfunctions is critical to the well being of your